U.S. ARMY

Center for Army Analysis

OPTIMAL STATIONING OF ARMY FORCES

JULY 2001

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Director
Center for Army Analysis
ATTN: CSCA-RA
6001 Goethals Road
Fort Belvoir, VA 22060-5230

CAA-R-01-42

REPORT DOCUMENTATION PAGE			*Form Approved* *OMB No. 074-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503			
1. AGENCY USE ONLY (Leave blank)	**2. REPORT DATE** July 2001	**3. REPORT TYPE AND DATES COVERED** Final, May 2000 – July 2001	
4. TITLE AND SUBTITLE Optimal Stationing of Army Forces (OSAF)			**5. FUNDING NUMBER**
6. AUTHOR(S) LTC William J. Tarantino, Mr. Gary Connors			
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Center for Army Analysis** **6001 Goethals Road** **Fort Belvoir, VA 22060-5230**			**8. PERFORMING ORGANIZATION REPORT NUMBER** CAA-R-01-42
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Assistant Chief of Staff for Installation Management ATTN: DAIM-ZA 600 Army Pentagon, Rm 1E668 Washington, DC 20310-0600			**10. SPONSORING / MONITORING AGENCY REPORT NUMBER**
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; dissemination unlimited			**12b. DISTRIBUTION CODE** A
13. ABSTRACT *(Maximum 200 Words)* The Assistant Chief of Staff for Installation Management tasked the Center for Army Analysis (CAA) to develop and demonstrate an analytical capability to systematically examine Army stationing alternatives. The alternatives are distinguishable by the force structure, amount of implementation dollars available, and stationing restrictions. These elements and installation capacities comprise the analytical framework and are the primary model inputs, and each is discussed in detail in this report.			
14. SUBJECT TERMS Base Realignment and Closure (BRAC), Efficient Facilities Initiative (EFI), integer program, Army stationing, facility location problem			**15. NUMBER OF PAGES**
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	**18. SECURITY CLASSIFICATION OF THIS PAGE** UNCLASSIFIED	**19. SECURITY CLASSIFICATION OF ABSTRACT** UNCLASSIFIED	**20. LIMITATION OF ABSTRACT•** SAR

NSN 7540-01-280-5500
Standard Form 298

20020220 101

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OPTIMAL STATIONING OF ARMY FORCES (OSAF)

SUMMARY

THE PROJECT PURPOSE is to develop and demonstrate an analytical capability that can systematically examine Army stationing alternatives and prescribe an optimal Army stationing for a given force structure, set of installations, available implementation dollars, and stationing restrictions. We call this analytical capability OSAF, the Optimal Stationing of Army Forces.

THE PROJECT SPONSOR was the Assistant Chief of Staff for Installation Management (DAIM-ZA), Headquarters, Department of the Army.

THE PROJECT OBJECTIVES

(1) Determine the optimal stationing of Army forces given the force and associated installation support requirements.

(2) Provide an analytical approach to examine stationing alternatives for a given Army force structure for the Quadrennial Defense Review.

(3) Examine Army facility utilization and determine potential improvements through stationing. Determine facility capacity factors for different stationing alternatives.

(4) Determine costs and potential savings for stationing alternatives.

THE SCOPE OF THE PROJECT. The Deputy Chief of Staff for Operations and Plans (ODCSOPS) categorizes Army installations based on the installation's primary mission. OSAF addresses five different installation types in the continental US (CONUS): maneuver, command and control, professional schools, major training areas, and training schools as well as a number of leased facilities. OSAF includes each installation's available heavy and light maneuver training capacity, ranges, and facilities, and unit requirements for these assets. In this report, we consider the current force structure consisting of 514 major units on 43 installations. We also consider the National Guard and Reserve Component requirements.

THE MAIN ASSUMPTIONS

(1) The Department of Defense (DOD) or the Army will pay environmental remediation costs for the majority of Army bases over the next 50 years. We assume these costs for any closing installation could be accelerated.

(2) We can aggregate similar facility category groups with minimal loss of solution fidelity.

(3) For each installation, the single metric, days, adequately portrays its range availability and kilometer square days (KM^2Days) adequately portrays its heavy and light maneuver land availability.

(4) The local community surrounding an installation can meet housing and utility requirements that are not satisfied by an installation's assets.

(5) When OSAF recommends moving all active component units from an installation (inactivating the installation), Army Reserve and National Guard units remain behind in an enclave along with non-DOD tenants.

THE PRINCIPAL FINDINGS

(1) OSAF substantially increases the Army's stationing analysis capabilities. Specifically, OSAF's optimization approach improves the speed, rigor, and the ability to conduct systematic sensitivity/what-if analysis, in support of Army stationing.

(2) An Army-wide stationing that considers multiple unit movements could potentially save the Army billions of dollars (net present value). Savings are not realized for many years because of the implementation costs involved.

(3) Limiting stationing alternatives to installations of the same "type" or "stove piping" can significantly decrease opportunities to save stationing dollars. For example, limiting stationing alternatives for maneuver installation units to only other maneuver installations ignores the potential efficiencies of moving these units to different types of installations.

(4) Varying maneuver land availability increases opportunities to station and supports the development of real estate acquisition strategies.

(5) OSAF seldom recommends inactivating installations with maneuver land except when units with a light maneuver requirement can use heavy training lands.

(6) OSAF prefers a smaller set of large multipurpose installations instead of smaller limited purpose installations.

(7) A cost saving unit-stationing action can trigger a complex series of additional unit moves.

(8) A stationing alternative must be evaluated using a family of metrics, both quantitative and qualitative.

THE PRINCIPAL RECOMMENDATIONS

(1) The Army should determine stationing based on unit requirements, and an installation's ability to meet those requirements. It should avoid stove piping.

(2) Net present value should be used as one of several metrics to determine the value of an alternative.

(3) OSAF does not include potential savings from efficiencies in manpower gained by stationing like units at the same installation; however, it could include these efficiencies if

estimates were available. We recommend further work be completed in this area to determine possible efficiencies.

(4) Joint Service cooperation and National Guard and Reserve installations (and possibly training lands) are another source of possible efficiencies and should be pursued in future stationing analysis.

THE PROJECT EFFORT was directed by LTC William J. Tarantino, Resource Analysis Division, Center for Army Analysis (CAA).

COMMENTS AND QUESTIONS may be sent to the Director, Center for Army Analysis, ATTN: CSCA-RA, 6001 Goethals Road, Suite 102, Fort Belvoir, VA 22060-5230.

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1 INTRODUCTION

1.1 Optimal Stationing of Army Forces (OSAF)

CAA developed the Optimal Stationing of Army Forces (OSAF) analytical capability for the Assistant Chief of Staff for Installation Management (ACSIM), Headquarters, Department of the Army.

1.2 Purpose

The purpose of OSAF is to develop and demonstrate an analytical capability that can systematically examine Army stationing alternatives and prescribe an optimal Army stationing for a given force structure, set of installations, available implementation dollars, and stationing restrictions. We call this analytical capability OSAF, the Optimal Stationing of Army Forces.

At the center of the OSAF capability is an integer linear program (ILP) that determines the optimal stationing of Army units in a given force structure.

1.3 Background

The Quadrennial Defense Review (QDR) asks the overarching question, "What are the infrastructure requirements to support the Army of the future?" The ACSIM tasked CAA to develop an analytical capability to assist him in answering this question.

OSAF specifically addresses the "Installation Support" activity area of the DOD infrastructure coding system for Future Years Defense Plan (FYDP) program elements.[1]

OSAF focuses on a unit's facilities and training requirements (Army "demands"), an installations capability to meet these requirements ("supply"), and the cost to operate units on different installations.

Alternatives must be feasible. To that end, the model ensures assets are available to meet requirements; however, there are stationing restrictions that add another facet to feasibility. For example, a unit may require a specific type of terrain, geographical location, or a special characteristic that limits its stationing. These special requirements are addressed in the model through stationing restrictions (additional model constraints).

OSAF is a macro stationing analysis. Other models that address specific elements in OSAF (e.g., Army Range Requirements Model (ARRM) for training) can be used for more in-depth or detailed stationing analyses. OSAF is not a replacement for the stationing process outlined in Army Regulation (AR) 5-10. Instead, it is a starting point for developing and examining alternative stationing scenarios.

[1] Program Analysis and Evaluation (PAE) Program Objective Memorandum (POM) Guidance: infrastructure consists of Installation Support, Acquisition Support, Force Management; and Central--C3, Training, Personnel, Medical, and Logistics.

1.4 OSAF Scope

In this report, we examine the current Army force structure (Figure 1). Specifically, OSAF stations today's forces on a given set of installations at least cost while meeting unit requirements. Each "alternative" stationing solution ensures all units are stationed within stationing restrictions and is examined with a set of quantitative and qualitative metrics.

- ❑ Installation types (CONUS only) :
  - Maneuver (11 Installations)
  - Command, Control/Administrative Support (11)
  - Professional Schools (4)
  - Major Training Areas (4)
  - Training Schools (13)
  - Major leased facilities (43)
- ❑ Ranges (8), maneuver lands (heavy and light), and facility assets at each installation (39).
- ❑ Forces (514 units):
  - All Active Component units for possible restationing.
  - National Guard and Reserve Components for training and facility requirements.

Figure 1. OSAF Scope

The Deputy Chief of Staff for Operations and Plans (ODCSOPS) categorizes Army installations based on the installation's primary mission. OSAF addresses five different installation types in the continental US (CONUS): maneuver, command and control, professional schools, major training areas, and training schools as well as a number of leased facilities. OSAF includes each installation's available heavy and light maneuver training capacity, ranges, and facilities, and unit requirements for these assets. In this report, we consider the current force structure consisting of 514 major units on 43 installations. We also consider the National Guard and Reserve Component requirements.

OSAF does not include the commodity or logistics type installations (a complete listing of included and excluded installations is in Appendix I). Their exclusion is due to the differences in the requisite requirements of units stationed at OSAF type installations versus commodity/ logistic types, which include depots, arsenals, proving grounds, industrial facilities, and ammunition installations. A separate OSAF type model could be developed to address these other installation types; however, it would be based on manufacturing processes or other metric(s). If an installation not in OSAF should be considered as a possible destination for OSAF units, we could add the installation to the model.

The ARRM database contains the following range types.

- Basic weapons ranges: zero ranges, record fire, sniper, pistol qualification, machinegun, 40mm grenade machinegun, LAW/AT4, antiarmor live fire and tracking, and M203 grenade launcher.

- Collective live fire ranges: aerial gunnery, infantry platoon battle courses, infantry squad battle courses, and multipurpose range complexes/CALFEX.

- Special purpose ranges: hand grenade qualification, hand grenade live fire familiarization, demolitions/flame, and engineer qualification.

OSAF includes the eight most influential range types (highest weights in Installation Training Capacity (ITC)). Additional range types can be added to the model as ARRM data matures and becomes available.

OSAF includes heavy and light maneuver unit requirements and installation capacities.

The model accounts for all units (and requirements) that are currently stationed on the OSAF installations (514 Real Property Planning and Analysis System (RPLANS) major units; see Appendix N for a listing of major units) and stations Active Component units. OSAF includes the National Guard and Reserve Component requirements [DODI 1225.8]; however, it does not station their units. It is important to note that Reserve and National Guard training and facility requirements are accounted for in all alternatives. This precludes the model from moving an Active Component unit to an installation where facilities are currently used for other component's missions [ACSIM/ODCSOPS Guidance].

The units are a derivative of force structure. By solving OSAF with different force structures, we can compare stationing alternatives for current Army units as well as future units. This capability helps to identify short-term realignments and closures that could negatively impact future requirements.

1.5 Army Installation Types

- ☐ CAA-OSAF
  - Maneuver (11 Installations)
  - Major Training Areas (5)
  - Command, Control/Admin Support (9)
  - Training Schools (14)
  - Professional Schools (4)
- ☐ RAND Right-sizing Study
  - Ammunition Storage Facilities (9)
  - Army Production Facilities (13/9 active)
  - Commodity Oriented (8)
  - Industrial (3)
- ☐ Other
  - Depots (5)
  - Medical Centers (5)
  - Ports (1)
  - Proving Grounds (3)

ODCSOPS

Stationing Analysis

2002

Figure 2. Army Installation Types

Figure 2 lists the 13 types of Army installations [ODCSOPS Stationing Strategy (Draft) 2001]. OSAF considers the five types of installations listed in Figure 2. RAND is currently considering four additional types in their Right Sizing Study. ODCSOPS includes all installation types in their current stationing strategy review and the 2002 stationing analysis.

1.6 Key Assumptions

(1) The Department of Defense (DOD) or the Army will pay environmental remediation costs for the majority of Army bases over the next 50 years. We assume these costs for any closing installation could be accelerated.

Impact: This could influence other remediation actions and limit closures in the short term.

(2) We can aggregate similar facility category groups with minimal loss of solution fidelity.

Impact: A micro-analysis needs to be completed that examines OSAF alternatives. Such an analysis would examine additional stationing details (Unit Relocation Cost Model (URCM) task).

(3) For each installation, the single metric, days, adequately portrays its range availability and KM^2Days adequately portrays its heavy and light maneuver land availability.

Impact: Treating KM^2Days and range days as a linear commodity could provide an optimistic portrayal of maneuver land availability. This assumption requires efficient use of resources by installation range/land users.

(4) The local community surrounding an installation can meet housing and utility requirements that are not satisfied by an installation's assets.

Impact: In remote areas, this assumption may be overly ambitious. We reexamine possible impacts in the model's postprocessing.

(5) When OSAF recommends moving all Active Component units from an installation (inactivating the installation), Army Reserve and National Guard units remain behind in an enclave along with non-DOD tenants.

Impact: An enclave versus closing status ensures installation availability, limits to some extent environmental cleanup impacts, and provides Reserve and National Guard additional stationing assets.

1.7 Key Limitations

OSAF limitations exist due to modeling characteristics or data and decision rule availability. OSAF's structure can currently accommodate aspects of the limitations highlighted in Figure 3, and additional features could be added to OSAF beyond these key limitations, if an Army-wide approved database and decisions rules for key metrics existed (see Appendix Q).

- ❑ OSAF does not capture ALL stationing details regarding force structures and resources (e.g., not all facilities).
- ❑ National Guard and Reserve forces maintain installation assignments.
- ❑ OSAF does not include other Service installations and any Joint use possibilities.
- ❑ OSAF recognizes savings from reduced installation support overhead, but not additional operational efficiencies from combining two units of the same type at one installation.

Figure 3. Key Limitations

1. All stationing details. OSAF is a mathematical model; as such, it cannot capture "all" details concerning realignment, but it needs to include the important ones that make a difference in stationing alternatives. For example, there are 353 Facility Category Groups (FCGs); however, the majority of these groups were irrelevant in past stationing actions. A set of FCGs

repeatedly surface as influential in the stationing process and should therefore be included in OSAF or other analyses. OSAF includes factors that influence the ability of an installation to successfully meet a unit's requirements.

2. National Guard and Reserves. We do not station National Guard and Reserve forces; however, if we included this possibility, additional efficiencies could be gained. The National Guard Bureau and ACSIM also have a Memorandum of Agreement to integrate Army National Guard data into the standard Army system ACSIM uses for stationing analysis. Once this integration is complete, their inclusion would be easier to facilitate. A separate OSAF type model could be appropriate for a National Guard and Reserve stationing analysis.

3. Joint Service installations. The most significant limitation, as far as solution flexibility, is the lack of other Services in the model. If OSAF included other Services, the Army would have additional resources available for stationing and possibly at a lower cost. Separate Service installations that are collocated geographically could be combined, providing a savings of fixed cost. When data and decision rules are available for inter-Service use, we highly recommend other Service installations be added to OSAF. Until then, OSAF does have the ability to examine possible Joint Service scenarios by adding notional installations as destinations as long as distances between installations, available resources, and a cost structure exists for this notional installation.

We believe the General Accounting Office's (GAO) suggestion that DOD should resolve, "in advance, key organizational and policy issues, such as what Service or Services will be responsible for which support functions" [GAO/NSIAD-97-151, p 4], would be prudent and essential for any joint Service cooperation (similar to DOD Directive 1225.7, which addresses joint use of facilities for Reserve Components).

More than the responsibility of functions, a simple agreement for joint stationing analysis in geographical areas with a high density of installations would be beneficial.

4. Operational efficiencies. When Army units (as well as Joint) are combined on the same installation, potential efficiencies are gained owing to the possible sharing of resources (i.e., less staff, fewer redundancies). OSAF does not include these potential savings; however, it could include them if estimates for these efficiencies were available. Other operational efficiencies made possible when units are combined can be measured from the facility, range, and cost perspective. OSAF cannot measure OPTEMPO or other operational improvements.

1.8 OSAF: Input – Output

Each installation has capabilities, costs, and units, which comprise model "inputs". OSAF "output" is a stationing alternative with appropriate reports.

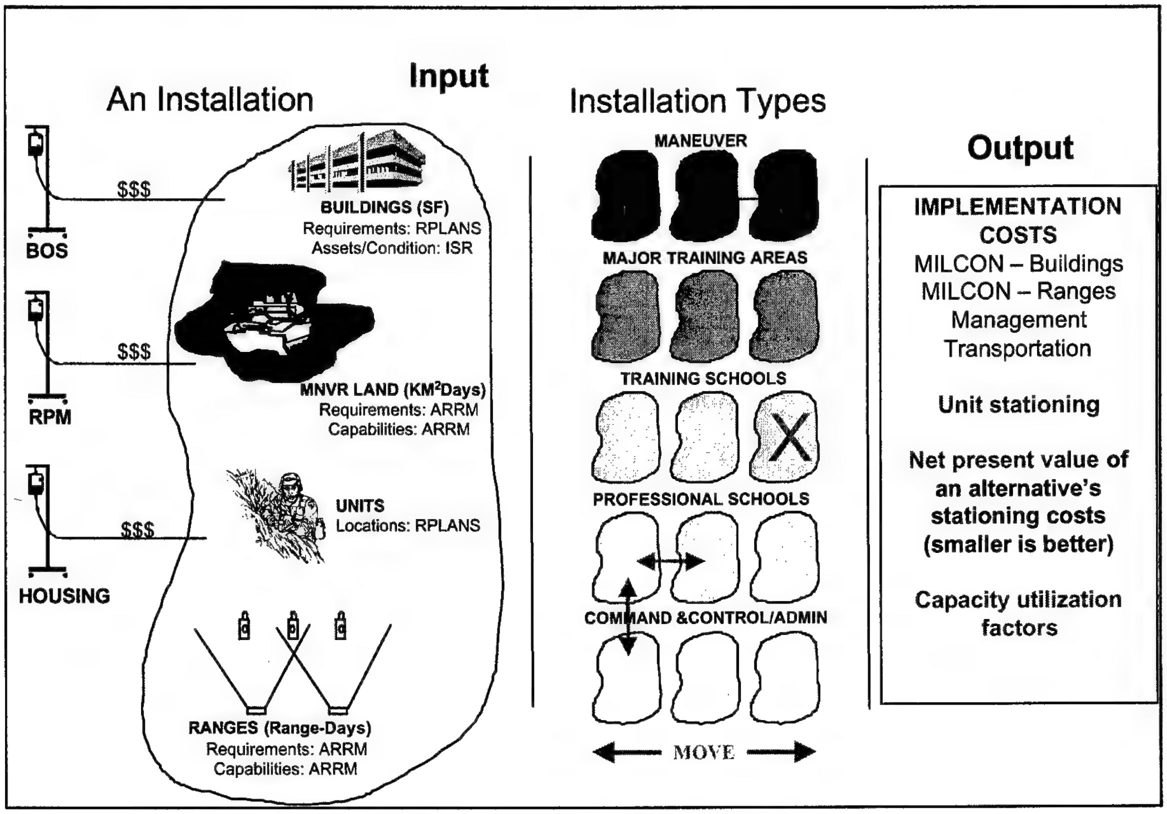


Figure 4. OSAF: Input - Output

OSAF installations have different types of buildings that belong to various FCGs. The Real Property Planning and Analysis System (RPLANS) provides all unit FCG requirements and the Installation Status Report (ISR) provides the condition of these facilities. The units stationed on an installation drive all requirements, which RPLANS also provides.

ARRM provides all maneuver land and range information (requirements and capabilities).

The three primary budget programs that support OSAF installations are:

1. Base Operating Support (BOS) costs,
2. Real Property Maintenance Costs (RPM), and
3. Housing costs.

The left side of Figure 4 illustrates an installation and the above elements. On the right side of Figure 4 are the five OSAF installation types (e.g., maneuver) with three land mass figures that represent the numerous installations that OSAF can use for the stationing of units. An arrow represents allowable movement of a unit from one installation to another. Constraining movement within an installation type is referred to as "stove piping." Stove piping limits potential realignments (e.g., the movement from a Professional School to the Command and Control installation in Figure 4), and we use OSAF to investigate its impact. Without stove piping, any unit can move and be stationed at any other OSAF installation. An "X" on Figure 4 represents an inactivated installation[2].

OSAF produces the outputs listed on the far right of Figure 4. Outputs includes a stationing alternative comprised of a complete stationing of all units and the associated implementation costs for military construction (MILCON), transportation, and program management (closures and movements); the net present value (NPV) of the stationing alternative for a 20-year period (can be varied), and the capacity utilization of both facilities and ranges.

[2] If an installation is deactivated in OSAF, we assume the Army Reserve and National Guard units remain in enclave along with non-DOD tenants.

1.9 Questions for OSAF

Figure 5 lists some of the questions OSAF can help answer (not meant to be an exhaustive list).

1. QDR ISSUE -- What are the **infrastructure requirements** needed to support alternative force structures (existing and other stationing plans)?
2. Which Active Component **units should be stationed where** based on training requirements, facility requirements, and cost?
3. What facility types and/or **cost drivers** significantly impact stationing solutions?
4. What is the **one time cost** to improve infrastructure to an Installation Status Report (ISR) level Green for various force structures?
5. Does "**stove piping**" by installation type or other restationing restriction limit potentially favorable alternatives?
6. "**What if**" analysis (provide the impact on facilities, training, and costs):
   - What installations become excess if we follow alternative #X?
   - What if the Army puts a brigade at "X"?
   - What is the best location for unit "Y"?
7. What is the **capacity utilization** of the infrastructure and training assets for alternative stationing?
8. **What are possible costs and savings for stationing alternatives?**

Figure 5. Questions for OSAF

1. What are the ***infrastructure requirements*** needed to support alternative force structures? RPLANS provides facility requirements and ARRM provides training range and land requirements for each unit. Given the force structure, OSAF can then determine infrastructure requirements for a set of facilities, range types, and maneuver lands. We have examined these requirements for the current Army force structure and can do the same for future force structures (given units and their requirements).

2. Which Active Component ***units should be stationed where*** based on training requirements, facility requirements, and cost? OSAF considers unit training and facility requirements and matches them with installations that can best satisfy requirements. Additionally, OSAF matches requirements (demands) to installations (supply) in a cost efficient manner. The Army force structure drives what units OSAF stations.

3. What facility types and/or ***cost drivers*** significantly impact stationing solutions? Post-analysis of BRAC 95 actions provides numerous insights on expected cost drivers for past decisions. With OSAF we can determine what cost element is driving alternatives and what

element is inconsequential (not necessarily an irrelevant or trivial expense, but does not drive recommendations).

4. What is the ***one-time cost*** to improve infrastructure to an Installation Status Report (ISR) level "green" for various force structures? The ISR provides the condition of all facilities (green, amber, red) and the quantities of each facility by condition at each installation. OSAF determines the cost to take Army facilities from amber and red condition to a green level.

5. Does "***stove piping***" by installation type or other stationing restriction limit potentially favorable alternatives? Stove piping is a constraint that limits potential stationing actions. One question we need to answer for ACSIM--how much does this constraint limit more favorable alternatives?

6. "***What if***" analysis provides the impact on facilities, training, and costs for different stationing actions. OSAF's what-if capability is a key analytical strength. From any stationing alternative we can examine single moves, installations closing, forced actions, stationing restrictions, and cost limitations.

7. What is the ***capacity utilization*** of the infrastructure and training assets for alternative stationing? If an installation has 100 square feet of facilities and all the units on the installation require a total of 90 square feet (SF), then the capacity utilization factor is 90 percent. Ideally the Army would have high capacity utilization factors for facilities, ranges, and training lands. OSAF projects these factors for all alternatives.

8. ***Cost Analysis*** provides an idea of the economies that the Army might achieve through a stationing exercise. Costs and resulting savings are *estimates* based on the best information available. History has shown that even with the complexity of moving units and inactivating installations, cost estimates are adequate for planning purposes.

1.10 Differences from Past Analyses

Before we discuss the OSAF Model's formulation details and its different data elements, we should distinguish between the past stationing analyses and the OSAF approach. Past analyses provide us a starting point, insights into potential cost drivers, and pitfalls to avoid. The following are four major differences between two approaches (BRAC 95 and OSAF).

BRAC 95 Approach	OSAF Approach
1. Completed a detailed installation and military value assessment with subjective weights for numerous installation characteristics. These evaluations controlled alternatives.	**1. OSAF examines EVERY alternative with respect to facility and training requirements, mission-related restrictions, and economics.**
2. Examined the "payback" for one scenario at a time (spreadsheet analysis).	**2. Simultaneously considers multiple unit movements and net present value (NPV).**
3. Conducted "stove pipe" analysis.	**3. Analysis has "restationing restrictions;" However, we do not restrict restationing among installation types.**
4. Exempts 26 installations from possible closure action.	**4. Restationing action is driven by an installation's ability to help satisfy Army requirements.**

Figure 6. Differences from Past Analyses

1. The BRAC 95 approach started with a detailed installation and military value assessment with *estimated weights* for numerous installation characteristics (see Appendix H). For example, a command and control installation could get a maximum of 140 points for their operations and administrative facilities out of 450 points in the Mission Requirements and Operational Readiness Category [DOA, Installation Assessment Process and Supporting Data, Volume II, March 1995, p 62]. The Army evaluated installations on numerous categories, summed the weighted scores, and ranked installations. These rankings would limit the stationing alternatives. OSAF does not weight any of the parameters in the model. Instead, **OSAF examines all alternatives with respect to facility and training requirements, and economics (costs, savings, and NPV), constrained by mission related restrictions**. This approach is more objective in nature, which we maintain by limiting additional stationing restrictions.

2. BRAC 95 stressed the "payback" metric to evaluate an alternative (the period it takes for savings to exceed implementation costs) and used the Cost of Base Realignment Actions (COBRA) Model to complete this analysis. If an alternative did not meet the payback cutoff, it was discarded. Unfortunately, this short-term approach ensures the same issues remain unsolved in perpetuity and favors short-term gains over long-term savings. Another shortfall of this approach is that it may not consider systems or multiple moves simultaneously between different sets of installations. Theoretically, one costly move could enable several other moves, which in the long run (20-year period) could result in considerable savings. If the one costly move is discarded due to a bad payback period, then the other moves are not possible, which disallows the potential savings. **OSAF simultaneously considers multiple unit movements and net present value (NPV).** The NPV metric allows for a long-term perspective and follows GAO guidance to "use the current discount rate tied to the U.S. Treasury's borrowing rate to calculate the net present value" [GAO/NSIAD-97-151, p 51] for these types of actions.

3. Stove piping or restricting stationing between similar types of installations typified past analysis. Such restrictions limit potential savings. **OSAF analysis has "stationing restrictions;" however, we do not restrict stationing among installation types.** All OSAF restrictions are mission, environmental, and requirements driven and not artificial limitations. In the past, the "Army's process began by categorizing installations according to their current functions, broader alternative uses were not considered." [RAND xvii] OSAF considers the broadest of possible alternatives.

4. BRAC 95 exempted 26 installations from closure owing to their weighting of installations highlighted above. **In OSAF, stationing action is driven by an installation's ability to help satisfy Army requirements.** The distinction is important because it provides a more objective process and a larger solution space. An installation in OSAF is not essential because a particular unit is assigned there; it is essential because it has the assets needed to meet total Army requirements. OSAF knows a unit's requirements and stations the unit to an installation if the installation can meet those requirements at a low cost.

1.11 Differences from Other Available Models

ACSIM and DCSOPS have numerous models that can assist them with stationing analysis. The primary model of interest besides OSAF is the Unit Relocation Cost Model (URCM), which is the follow on work to the Cost of Base Realignment Actions (COBRA) model.

COBRA/URCM Model	OSAF
User must develop alternative outside of COBRA model – limited number of units and installations – labor and time intensive (several day process) – cannot ensure feasibility of alternatives	Model generates alternative stationing plan. – Larger set of installations and all units – runs in 2-10 minutes – ensures feasibility and optimality
Calculates the cost of stationing regarding facility, transportation, and management – one alternative at a time – requires many models' outputs for full picture	Examines stationing with respect to facility and training requirements, mission related restrictions, and implementation costs. – considers all alternative stationing plans – integrates across models
Does not readily allow sensitivity analysis	Can systematically perform sensitivity and what-if analysis.
	Incorporates URCM with an economic analysis for the optimal alternative.

Figure 7. Differences from Other Models

URCM is a spreadsheet-based model. The user establishes the stationing alternative with a brainstorming session where a group of analysts determine the units to move and installations to close. This "scenario" is input for URCM, which calculates the associated costs and savings for the moves; optimization is not involved. This development phase is data intensive and can take several days to fulfill and then additional time to examine the results. Prior to analyzing the scenario there is no assurance of feasibility or optimality; sensitivity analysis is cumbersome. URCM includes all facility requirements; however, it does not include training information. Instead, the analyst uses a separate model to see the scenario's impacts on training ranges and maneuver lands.

The OSAF model is optimization based. It examines all feasible alternatives simultaneously, given a set of data, constraints, and an objective function. The optimization approach provides the capability to examine multiple alternatives with competing requirements and costs in one integrated model. Like URCM, OSAF includes facility requirements, but it also includes training ranges and maneuver lands. The OSAF integer linear programming model (ILP) can complete a model run in 2-10 minutes and allows the user to systematically conduct sensitivity

analysis. An integral part of the OSAF methodology is the incorporation of URCM into the economic analysis of the optimal alternative.

1.11.1 Installation Support Cost Model

The Installation Support Cost Model (ISCM), like URCM, is a spreadsheet-based model. The user establishes the stationing alternative, and in ISCM's case, the model determines a generic or average installation type with associated costs and savings; optimization is not involved. Both models require significant user inputs and examine one scenario at a time.

ISCM has a DOD-wide perspective, but generates cost and facility profiles for a generic-virtual installation using average cost data for different installation types.

1.11.2 Integer linear programming

Integer linear programming (ILP) has been used to some level of success in assisting the Army with their stationing efforts. The Total Army Basing Study office used Optimally Stationing Units to Bases (OSUB) to suggest stationing alternatives during past BRAC processes [Dell, et al., 1994]. OSUB maximizes the military value of maneuver and training installations using weighted factors from BRAC military value assessments, or OSUB minimizes yearly operating cost, or it uses a combination of the two. OSAF builds on OSUB. In contrast to OSUB, OSAF contains additional installations, facility information, facility quality from the ISR, additional ranges, the new KM^2Days metric for maneuver lands, and additional cost categories; and OSAF minimizes the NPV of base operation, closure, and realignment costs.

Loerch et al. examined possible stationing policies for the European theater. Their model minimized annual cost subject to constrained resources, implementation costs, unit proximity, and support requirements [Loerch et al., 1996]. Other analyses including Singleton [1991], Tarantino [1992], and Free [1994], which were the earliest efforts to examine parts of the BRAC process using an integer programming approach. However, integer linear programming is not new to the facility location problem that best characterizes Army stationing and can be found throughout the Operations Research literature.

2 MODEL OVERVIEW

2.1 OSAF Methodology Summary

At the center of our approach is the OSAF integer linear program (ILP); the ILP enables objective evaluations of stationing alternatives for future Army force structures. The Army requires infrastructure (buildings and ranges). OSAF views infrastructure in aggregated facility and training assets (ranges and maneuver lands) and quantitatively measures shortfall in facility or training assets for stationing alternatives of various force structures.

Facility and training assets provide for an objective yardstick to compare stationing alternatives. Installations have a fixed cost to operate that is not dependent on unit loads; therefore, OSAF includes fixed costs as part of the NPV calculations. Because the yearly cost of maintaining facilities and ranges impacts the Army's ability to maintain facilities for training, OSAF includes the yearly recurring cost in NPV calculations, and a second objective function (run separately) minimizes the yearly recurring cost to maintain infrastructure at all installations for a given measure of shortfall. Because there could be a large one-time stationing cost to move units to different installations in order to achieve the minimum NPV or yearly recurring cost, OSAF can limit the maximum one-time cost. Thus, OSAF views a force-structure stationing as a tradeoff amongst shortfalls in facility and training assets, yearly recurring cost, fixed costs, and one-time stationing cost. OSAF provides alternatives for a given force structure by varying the allowed facility or range shortfall and one-time cost.

In summary, OSAF is an approach to address a very complex problem – an Army stationing analysis. The approach depends on guidance from the Army Stationing Team, feedback from higher fidelity models, and continuous process improvements – incorporating influential factors in the model or impact assessment.

Data inputs include units, installations, cost factors, and costing algorithms, as well as sponsor guidance. The overall driver for any stationing analysis is the Army Stationing Strategy. The Strategy provides conceptual guidance and in effect limits the stationing rules that need to be applied in the model.

OSAF takes all inputs and determines an alternative stationing plan for a given set of inputs and stationing rules. This alternative is a starting point for higher fidelity models to examine in detail. Establishing the starting point for stationing analysis is OSAF's added value to the stationing process. Instead of numerous analysts developing alternatives and examining them one at a time, OSAF examines all possibilities and determines the best alternative (within model tolerances).

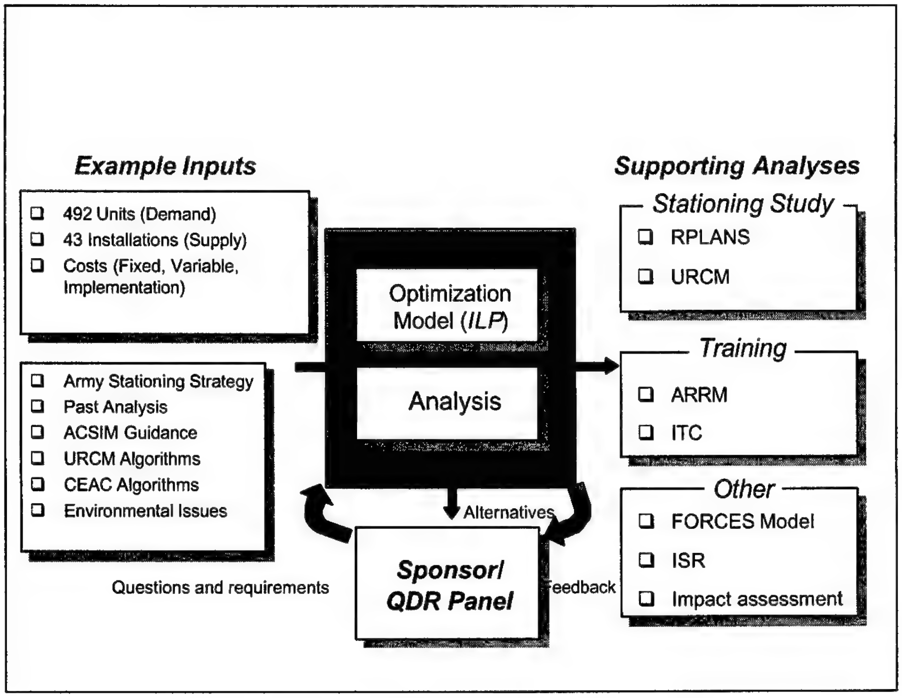


Figure 8. OSAF Methodology Summary

The OSAF ILP provides the starting point for further analyses with the supporting models shown on the right-hand side of Figure 8. After running the OSAF ILP, we complete an impact assessment that examines additional alternative details including strategic implications, political concerns, environmental issues, and impacts on deployment (other issues as needed).

2.2 Modeling Considerations and Assumptions

The following represent the key modeling considerations and assumptions in the OSAF ILP.

1. Cost. Cost is divided into recurring and one-time costs. Recurring costs are further divided into variable and fixed costs.

Every unit stationed generates variable costs associated with the installation operations. OSAF uses a derived value for the variable cost of stationing a unit on an installation based on three cost categories. These costs are base operating support (BOS), real property maintenance (RPM), and housing operations and allowances. Each operating installation also has a fixed cost that includes fixed base operating costs for Garrison activities and the minimum community facilities. Cost factors and relationships are from URCM, ISR, and other sources, which support the ACSIM with stationing related actions.

2. One-time Costs. One-time cost is divided into military construction (MILCON), transportation, and program management. We constrain OSAF by a maximum one-time cost available for all stationing actions. All stationing actions that include the movement of a unit or closure of an installation incur one-time costs in three major areas.

- Whenever a unit moves or an installation inactivates, one-time costs occur. These cost categories include the realignment's program management, caretaker, and mothball costs. (See Appendix G.) If a unit moves, it incurs a program and mothball cost; the caretaker cost is only added when an installation is deactivated.

- If an installation does not have the required facilities or ranges, then new military construction (MILCON) or an upgrade from "other" to "green" facilities is a one-time cost [URCM].

- All unit movements incur a one-time transportation cost [Forces and Organization Cost Estimating System--FORCES and URCM]. The transportation cost includes the movement of civilians, TDA equipment, military families, and the military unit. We assume a normal rotation policy for military personnel and their families, which decreases the movement costs associated with a stationing action.

3. Facilities. An FCG represents an installation facility or building type (e.g., administrative space). There are 353 FCGs [DA PAM 415-28]; however, a handful of these 353 provide the majority of the square footage units required [RPLANS] and were significant factors in past BRAC studies (see Appendix R) [BRAC 95 archives]. OSAF models 30 FCGs aggregated into 8 similar groups (see Figure G-11).

4. Facility Quality. The Installation Status Report (ISR) provides a quality rating (green=good, yellow=fair, or red=poor) for each square foot of each FCG at each installation. OSAF combines these groups into green and "Other." OSAF assumes any unit stationed to a new installation is given green-rated facilities or new construction. If only "Other" facilities are available, an upgrade cost is applied to upgrade the facilities to green. OSAF does not upgrade the facilities for units that remain on an installation (units that do not move) and assumes that green facilities are the last ones to be evacuated by leaving units [ACSIM guidance]. See Appendix G for a complete description of ISR application in OSAF.

5. Training. OSAF uses metrics from the ODSCOPS' new Installation Training Capacity and Army Range Requirements Model (ITC/ARRM) that provides maneuver and range day requirements [ITC Study Methodology, 8 July 1999]. Range requirements are expressed in range days and maneuver land requirements expressed in KM^2days. OSAF restricts the deviation between the required and available training assets. In so doing, it can ensure that moving units do not increase training asset shortfalls. A subset of units can train at installations where they are not assigned.

6. Installations. The OSAF Model includes 43 installations (see Appendix I). Each of these installations has similar characteristics, which allows us to include them in one model. Additional Army installations and other Service installations could be added to the model if they have facilities, ranges, and training lands that Army units can use and the potential usage rates and resources were known.

g. Units. We include all units that are currently stationed on an installation included in OSAF; this is not a requirement for the model. We can include any Army unit for stationing purposes as long as we know its current location and requirements.

2.3 OSAF Model Objectives

OSAF has an option for using either of two objective functions (Figure 9). The first objective function minimizes the net present value (NPV) for all fixed and recurring costs over a given time period. The second alternative objective function minimizes annual variable and fixed cost and a weighted (penalty) contribution for one-time cost. The NPV approach is the preferred objective because it has a long-term perspective and provides a recognized methodology for weighting costs (time-value of money).

Objective: Minimize NPV (Variable + Fixed + Implementation Costs over a 20-year period)

Alternative Objective: Minimize Variable + Fixed + Penalty * Implementation Costs

- Variable: Base Operating Support (BOS)+Real Property Maintenance (RPMA)+Housing and Quarters
- Fixed: Costs incurred if installation is open (BOS, Garrison)
- Implementation (up-front costs): Construction (Buildings)+Construction (Ranges)+Program (Program management, mothball, caretaker)+Moving

Figure 9. OSAF Model Objective

The variable cost element represents a cost per soldier or civilian assigned to an installation. Because variable costs differ between installations the model prefers installations with lower cost per soldier ratios.

Fixed costs are costs the Army pays regardless of the number of soldiers on the installation. The model chooses to deactivate an installation, if possible, to avoid paying 20 years of fixed costs (20 years is consistent with NPV analysis; however, OSAF can use any number of years).

Implementation costs represent the up-front or implementation cost required for a stationing action including:

- new construction and upgrade requirements for buildings and ranges,
- program (program management, mothball, caretaker) for all moving units and closing installations, and

- moving costs required to complete any stationing action.

We vary implementation costs to develop alternatives. For example, if we run OSAF, with zero implementation costs, we derive the status quo alternative. As we increase the amount of implementation dollars available, OSAF moves an increasing number of units and deactivates more installations. The model continues to consolidate until it cannot find a realignment that improves the 20-year NPV. At each new level of implementation funding OSAF generates the optimal solution and represents an alternative for Army stationing.

2.4 Model Constraints – Overview

Figure 10 is an overview of the model constraints (see Appendix F for a more complete discussion). Each constraint serves as a limit on the possible stationing alternatives.

1. Facility requirements and condition for each FCG Group
2. Range and KM^{2}day (Heavy and Light) requirements
3. Stationing requirements
4. Up-front cost categories
5. Stationing restrictions

Figure 10. Model Constraints - Overview

One set of constraints forces the model to provide all of a unit's required facilities to be in a certain condition. For example, if a unit moves from installation A to B, then these constraints ensure installation B has the required facilities for the unit in "green" condition (see Appendix F).

The second set of constraints is for ranges and training lands. OSAF ensures shortages in KM^{2}Days and range-days do not increase due to stationing of units. For example, if a unit requires 100 days on a zero range, then the model ensures the range-days are available on the installation, or the model will force the Army to buy the range-days on the installation to make up for shortages. If the shortage is greater than the minimum it will trigger new range construction. Although OSAF can buy ranges and facilities it cannot buy additional maneuver lands (see Appendix F).

We limit the total funds available for the up-front or implementation costs in the 4th set of constraints. For example, the total up-front cost could be one billion dollars. Or, we can limit up-front costs at the category level: $200M for MILCON and $2M for program management. Limiting the potential implementation dollars limits stationing options. Initial analysis shows that the majority of potential savings are realized with a minimum investment. Once this point is met then additional implementation dollars provide a marginal benefit.

2.5 Units and Stationing Restrictions

The last set of constraints is stationing restrictions, which represent special stationing considerations. These constraints are explained in this section and listed in Appendix J.

- **Source: 514 major units from Real Property Planning and Analysis System (RPLANS).**
  - Units grouped -- 330 groups
  - Apply stationing rules that restrict alternatives.
- **Example stationing rules that restrict unit assignment alternatives (from meetings with ODCSOPS and ACSIM):**
  - Group major units (e.g., six units at Ft Carson from 4th ID "grouped" into one unit).
  - USAR and ARNG units do not move.
  - TOE units in USARPAC limited to CA, WA, AK, and HI.
  - USDB in Leavenworth is fixed.
  - Field Artillery School must have impact area as least as big as the impact area at Fort Sill.
  - NSA does not move from their hardened facility at Fort Meade.
  - Apache Training Bde (Hood, Carson, Bliss).
  - West Point, Ft Irwin, and NG/Reserve training sites are fixed open.

Figure 11. Units and Stationing Restrictions

RPLANS provide the major units for the installations in OSAF. We currently group the 514 major units into 330 groups. Each group is then stationed together on an installation and cannot be broken into smaller units. (See Appendix N for a complete set of units and groups.)

The primary control on unit stationing is the stationing restrictions. A stationing restriction is any special stationing aspect that OSAF considers owing to a unit's special training or geographical requirement or an installation's unique resource. The rules develop over time as we use the model and discuss results with the ODCSOPS and ACSIM. OSAF can determine the cost of each stationing restriction and thus indicate how much the Army should be willing to pay

to complete tasks that would eliminate the need for a restriction. Figure 11 has several examples of stationing rules; a complete listing of rules as of publication is in Appendix J.

2.6 Environmental Costs

Environmental costs are an Army concern, both in and out of the stationing context. OSAF can account for these costs in two ways--treat them as solely a stationing cost, or apply them to the stationing process as a cost that stationing can impact. We choose the latter due to their existence regardless of stationing actions and because an installation closure could influence the remediation budgeting process.

DOD or the Army will probably pay environmental remediation costs regardless of an installation's eventual status; however, remediation costs could be accelerated if an installation is closed. Because these costs differ amongst installations and can be very large, the timeframe for payment can impact the entire remediation process and thus possibly influence the stationing process. Although past analysis chose to ignore these costs when developing alternatives, after action comments discussing these analyses suggest that these costs not be ignored. As these costs need to be considered somewhere in the process, we include them in the impact assessment.

Appendix E includes several environmental issues that could influence the stationing process. One such issue is remediation costs. Historical data shows that remediation costs are stochastic in nature, so estimated costs for project completion change from year to year. In fact, the one conclusion concerning these costs we can make with certainty is that they will change.

The question we address here is how these costs impact stationing and the Army stationing process. The Army has a plan to conduct remediation operations on OSAF installations (and all other installations).

Stationing would have the following impacts on this plan:

1) Move a unit from one installation to another – minimal impact.

2) Enclave – minimal impact.

3) Closure – compress years for project completion.

If an installation closes, then the number of years available to complete remediation could possibly be compressed. For example, if the Army closes Fort Carson, then the estimated years for completion, FY 17, could possibly be compressed to an earlier year. Regardless of the completion year, the impact would be:

1. A higher short-term cost for the cleanup at Fort Carson due to the accelerated action.

2. Dollars applied to Fort Carson could mean fewer dollars for the other projects and thus extend some other remediation timelines.

A second factor could force this value higher and that is these "other" costs not yet included in the remediation estimates (may be additional UXO or other unknown costs). To estimate these other possible costs, we could use past BRAC remediation cost to complete in 1995 compared to FY 2000 estimates. We find these estimates range from –93 percent to +350 percent, with an average of +10 percent.

If an enclave is included in an alternative, we also consider it a possible closing for remediation cost purposes and note that compressed remediation schedules could influence the entire remediation program.

3 WHY RESTATION?

3.1 Cost

The Army stations its forces to improve its operations and to reduce costs.

Paragraph 2.1 introduced the variable and fixed cost components in OSAF. If two installations have similar facilities that could satisfy Army requirements then a unit should be stationed on the installation with the lowest costs (barring other concerns or impacts). OSAF assigns units to installations that can meet their requirements at a low cost. The cost impacts and potential savings are evident in an example where we compare the variable costs (actual) incurred if the Army stations a unit on the different OSAF installations.

Consider a unit with 7,176 personnel stationed at an installation where the variable cost per soldier (housing and BOS) is $11,641. Other installations that could support the unit have variable costs ranging from $5,883 to $16,601. The stationing of this unit can thus cost the Army from $42 million to $119 million (actual variable stationing costs). At the unit's current location, the variable costs are $83 million; therefore, some installations offer potential savings for this unit. Of course, cost is not the only factor driving this stationing decision; however, it is one motivating factor to examine alternatives. A second potential area for cost savings is fixed cost. If an installation closes or deactivates, then the Army can reduce these fixed costs.

3.2 Capacity Utilization Perspective

One way to decrease costs is through the efficient use of available facilities. Theoretically, if the Army had excess facilities, then the movement of a unit that is short facilities to an installation with excess facilities could help satisfy the unit's requirements and lower costs (avoid new construction). Or, through the consolidation of unit requirements on installations with excess facilities, the newly freed space could lead to a deactivation or mothballing of facilities. In either case, the primary incentive to take advantage of the facilities is the cost involved and not the desire to improve facility utilization. The Army could have 100 percent utilization, but the cost would be prohibitive (implementation and long term); therefore, OSAF is making a tradeoff between the available facilities and cost for new facilities.

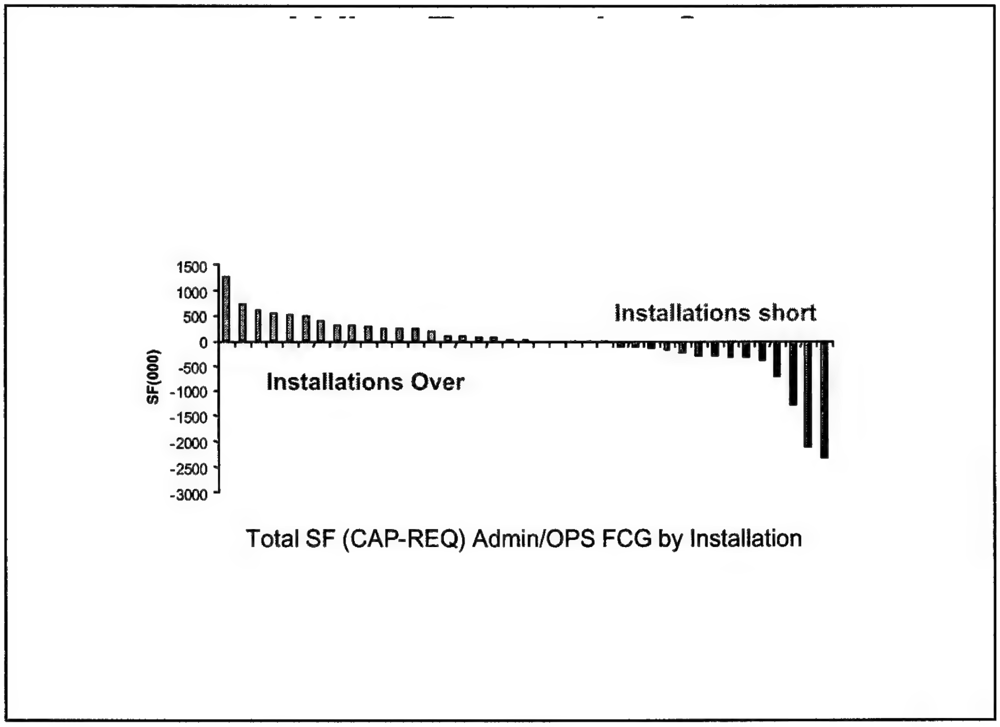


Figure 12. Capacity Utilization Perspective, Administrative Space

Figure 12 illustrates the current level of administrative/operations space on OSAF installations. Numerous installations have excess space (green), but others are short space (red). Theoretically, we could move forces to take advantage of the excess (green) administrative space. To take advantage of this space OSAF considers the SF, condition, cost to upgrade, and other implementation costs. Of course, the admin space example is one set of FCGs, and the Army cannot station based solely on this particular utilization. Instead, we need to consider many different FCGs, training ranges, and maneuver space utilization. Based on initial analysis of installation utilization space, we assume we can improve Army utilization factors at a lower cost, which is one possible reason to station.

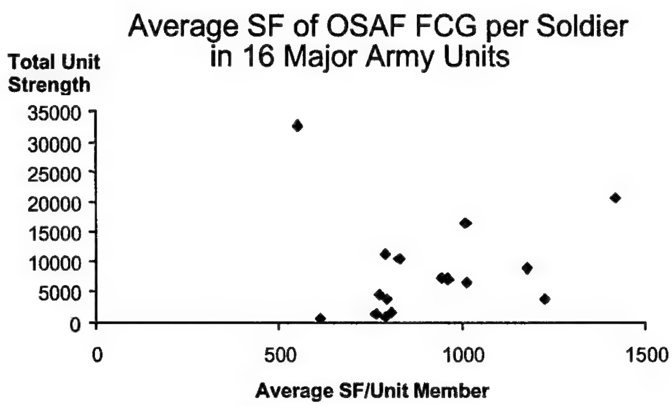
Some FCGs will continue to be short regardless of stationing while others could have excess facilities (e.g., supply and storage). Analysis shows that the Army could make up or lessen certain shortages with a stationing action; however, it is important to realize that shortages and overages are not always well placed on the available installations and moving a unit to take advantage of excess space may create shortage in another FCG or be cost prohibitive. It is also important to remember that if we station solely based on facility utilization, we could create a shortfall in training lands or ranges and increase recurring costs. OSAF considers installation facilities and provides a stationing alternative that considers all installations, their facility usage, training usage, and the cost of such facilities to ensure improvements in utilization will not impact other requirements.

If the Army deactivates an installation or loses force structure, the utilization picture may not be improved; it all depends on where the decrease in force structure occurs, the deactivated installation's facility utilization status, and the resulting amount of facilities mothballed.

GAO points out that the "DOD continues to maintain large amounts of excess infrastructure, especially in its support functions, such as maintenance depots, research and development laboratories, and test and evaluation centers." [GAO/NSIAD-97-151, p 3] We have found that excess infrastructure does exist in the OSAF installation types, but probably not to the same extent as GAO finds in the support type installations. OSAF attempts to correct part of this imbalance.

3.3 Does Force Structure Have Linear Facility Requirements?

It makes sense that as the Army loses force structure it also decreases facility requirements. One question the ACSIM asked us to investigate is the relationship between force structure and facility requirements. One way to examine this relationship is to determine if it is linear. For example, if the Army loses 10 percent of its force, will it lose 10 percent of its facility requirements?



Unit	SF	Personnel
1	0.4%	0.7%
2	0.6%	0.8%
3	0.9%	1.2%
4	1.0%	1.3%
5	3.7%	3.1%
6	2.4%	3.2%
7	2.8%	3.7%
8	5.2%	5.4%
9	5.3%	5.7%
10	5.4%	6.0%
11	8.1%	7.2%
12	6.8%	8.5%
13	6.9%	9.1%
14	12.7%	13.1%
15	15.5%	14.5%
16	22.3%	16.4%

%SF of total requirement (OSAF FCGs) and % personnel of all personnel of 16 major units.

Green ~ Personnel > SF req.

Figure 13. Average Square Footage

If we look at the required square footage per person for the 16 largest unit groups in OSAF, we see the SF requirement ranges from ~550 to ~1,400 SF per person. The per-person disparities tell us that if the Army loses 10 percent of the force, it does not necessarily require 10 percent fewer facilities. If we look at the table on the right of Figure 13, we see 12 of the 16 largest Army units have a greater percentage of personnel than their corresponding facility requirement and four have a lower percentage. According to this table the Army would lose a larger percentage of personnel than facilities for three-fourths of these major units; four units account

for the additional facility requirements. The bottom line is that the relationship between a unit's FCG requirement and personnel is not linear; therefore, reducing force structure may resolve some shortages in facilities but does not equate to an equivalent drop in facility requirements Army wide. Depending on what unit is lost the corresponding drop in facility requirements could even be larger then the percent loss in personnel (four of the 16 units).

Another point to consider is that even if unit #16 is taken out of the force (%SF > % personnel) and the requirements at the installation fall, unless the installation could meet all requirements prior to the loss, the percent improvement in the facility usage situation will not correspond to the percent size of the lost requirement.

3.4 Why Restation? Maneuver Land Perspective

A third reason to restation is to mitigate the imbalance of training lands throughout the Army. For example, if two installations have 100,000 KM^2days of training land and only 80,000 days in requirements, it would seem that the installations had adequate training lands; however, if one installation has 50,000 KM^2days and requires 60,000 KM^2days, then it would be short land. In fact, when we look at the overall Army perspective, the Army has enough training lands (gross of all lands), but with the current stationing plan, numerous installations are short--cannot meet their unit requirements. By stationing, we can *possibly* improve the balance between available lands and unit requirements throughout the Army.

The argument could be made that a third reason (in addition to cost and facility utilization) to station is to correct this imbalance of training lands. The complexity in this case arises because the majority of training lands are placed only in a few locations, which would require extensive relocation, implementation costs, MILCON, and have serious impacts on local communities. Additionally, the strategic implications could be significant; for example Alaska has over 50 percent of the light and over 30 percent of the Army's heavy maneuver lands (see Appendix K), but because it is also one of the highest cost areas and has environmental considerations, it is not the ideal location for the preponderance of US forces. This being the case, the Army can still take advantage of stationing to resolve ***some*** maneuver land shortages, but it will still be short, even after stationing, at some installations.

OSAF ensures that in each alternative the Army as a whole and each installation do not increase their maneuver land shortfalls. The model can also:

- tighten the constraint on maneuver land shortfalls for an installation or group of installations, which would force stationing to decrease or resolve shortfalls,
- relax the constraint on maneuver land shortfalls at the installation or Army level to see what additional lands will provide in the way of increasing stationing opportunities, and
- examine different schemes to alleviate shortfalls through land acquisition.

4 RESULTS

4.1 Strategy-Force Structure-Stationing

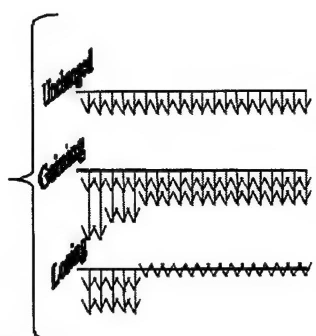
All stationing must adhere to the Army Stationing Strategy and force structure. The Army Stationing Strategy "provides general operational requirements, stationing guidance, and an operational blueprint for each installation category." The strategy limits or directs certain possibilities, and the force structure drives the unit and thus land, range, and facility requirements.

OSAF can accommodate strategic guidance and force structure changes through its data inputs and stationing restrictions. An example is the introduction of Interim Brigade Combat Teams (IBCTs) in the force. OSAF can include IBCTs by adding them as units with requirements and can then either force them on an installation or examine different stationing alternatives. A second example of a structure change would be the forced withdrawal from OCONUS installations. OSAF could include such units and examine potential stationing.

4.2 Key Result Metrics

The OSAF ILP prescribes stationing solutions; each solution or alternative should be measured against the following six metrics.

- ❑ Four metrics to evaluate results under realignment restrictions.
  - *Objective* – Minimize Net Present Value (NPV), the discounted value of all the Fixed +Variable + Implementation Costs over a given period (***smaller value is better***).
  - Implementation *Costs* – the up-front cost to implement an alternative.
  - *Complexity* of solution – how many units move; how many installations are affected.
  - *Capacity utilization factors* – how well the Army uses the available facilities.



Example: cash flows for NPV

- ❑ Payback period– the time it takes to recover up-front costs.
- ❑ Impact assessment (strategic, environment, deployment, other)

Figure 14. Key Result Metrics

- The objective function (smaller value is better)--for both objective functions (NPV and yearly costs) we measure a combination of fixed, variable, and implementation costs.

- Implementation or up-front costs--each alternative has an implementation cost for transportation, MILCON, and program management costs. The higher the allowed implementation cost, the greater the possibilities for stationing actions.

- Complexity of solution--each alternative has a number of units that are moved. The more units that move, the more complex it may be for the Army to implement. A solution with fewer moves is less complex but may be less favorable due to higher costs than other possible alternatives.

- Capacity utilization factors--stationing should improve the overall Army utilization factors for facilities, ranges, and lands, but this is a secondary concern. The primary concern is the availability of resources at least cost. If an optimal alternative has poor utilization, the Army could always move additional units to improve the utilization, but it will always be at an increased cost. We must remember that regardless of the resulting utilization, an alternative provides the optimal solution at a given implementation cost level; therefore, utilization should be considered and noted, but not drive additional stationing. A low utilization rate is not necessarily a reason to move an additional unit, but it could justify the mothballing of facilities.

4.2.1 Payback

- Past analysis concentrated on the payback period when evaluating a solution. The payback approach does not measure all possibilities because it denies moves that do not meet the required payback. But some moves with poor paybacks enable other moves, which, when combined, result in the best NPV. OSAF can measure and does calculate payback, but we do not recommend it as a factor to distinguish between alternatives. Instead, OSAF can examine individual moves in an alternative if they are not enabling of additional moves. The lowest payback moves tend to fall out of alternatives as available implementation costs are constrained. In this case, we agree with RAND's conclusion that "Options that require substantial up-front construction or other transition costs should not be dismissed out of hand before considering the net present value of the long term stream of costs and savings." [RAND, xvii]

4.2.2 Impact Assessment

- Because the above metrics cannot capture all considerations of such a complex process as the stationing of Army force, we examine all alternatives further with an impact assessment, which could be considered a postprocessing step. This assessment includes a panel's review for unique requirements not captured in OSAF as well as four key areas of interest including strategic implications, political constraints, environmental issues, and impacts on deployment.

- Strategic implications represent the Army's ability to fulfill its mission mainly from a geographical perspective. For example, the Army cannot put all forces on one coastline or a preponderance of forces in Alaska regardless of costs owing to other strategic concerns (e.g., homeland defense).

- Possible political "constraints" are examined in terms of their cost and possible impacts on alternatives. Each installation has its own set of political considerations; OSAF does not attempt to model these constraints. As Carter and Perry point out, "Every member of Congress

wants to reduce unnecessary defense spending, but no member wants to close a base or a government depot in their district" [Carter and Perry, 204]. If a political constraint is added to the model, OSAF can determine the cost of the constraint by solving with and without the constraint. From an Army perspective, this ability helps leadership determine what political constraints limit stationing.

- Environmental assessment includes remediation costs and an examination of possible concerns from the ERCM assessment in Appendix E. (ERCM is a component of the ITC that assesses environmental and demographic issues. ERCM does **not** preclude making stationing decisions on an installation; rather, it provides information to assist with environmental impact assessments.)

- Unit deployment requirements is a third key area of special interest that we include in our impact assessment; specifically, we determine if the stationing of a large maneuver force will stress existing deployment infrastructure at the unit's new location (e.g., railheads and airfields, see Appendix P).

- All inputs from OSAF and supporting analysis go to the sponsor for assessment. If an alternative has an unlikely stationing action, we can add restrictions, rerun the model, and determine the new level of implementation costs. The process requires feedback at multiple stages to eventually develop the final alternatives at different levels of funding. The OSAF approach attempts to minimize special constraints providing the widest range of possible alternatives and the best possible starting point to which we can then apply additional constraints. Once applied, we can determine the cost of the constraint and thus one form of potential impact from the additional stationing restriction.

4.3 Evaluating Results (example)

Figure 15 represents 10 different solutions (example) or alternative stationing actions at different levels of implementation cost using the minimize yearly cost objective function. Each point in the graph is the NPV and includes implementation costs. In the top graph, the Y-axis is in $10Bs, the status quo is the horizontal line ~$120B, and the X-axis represents the 10 alternatives. The bottom graph illustrates the level of implementation funding ($B). Alternative #1 has "0" possible implementation costs representing the status quo alternative. Alternative #10 has unlimited implementation funds.

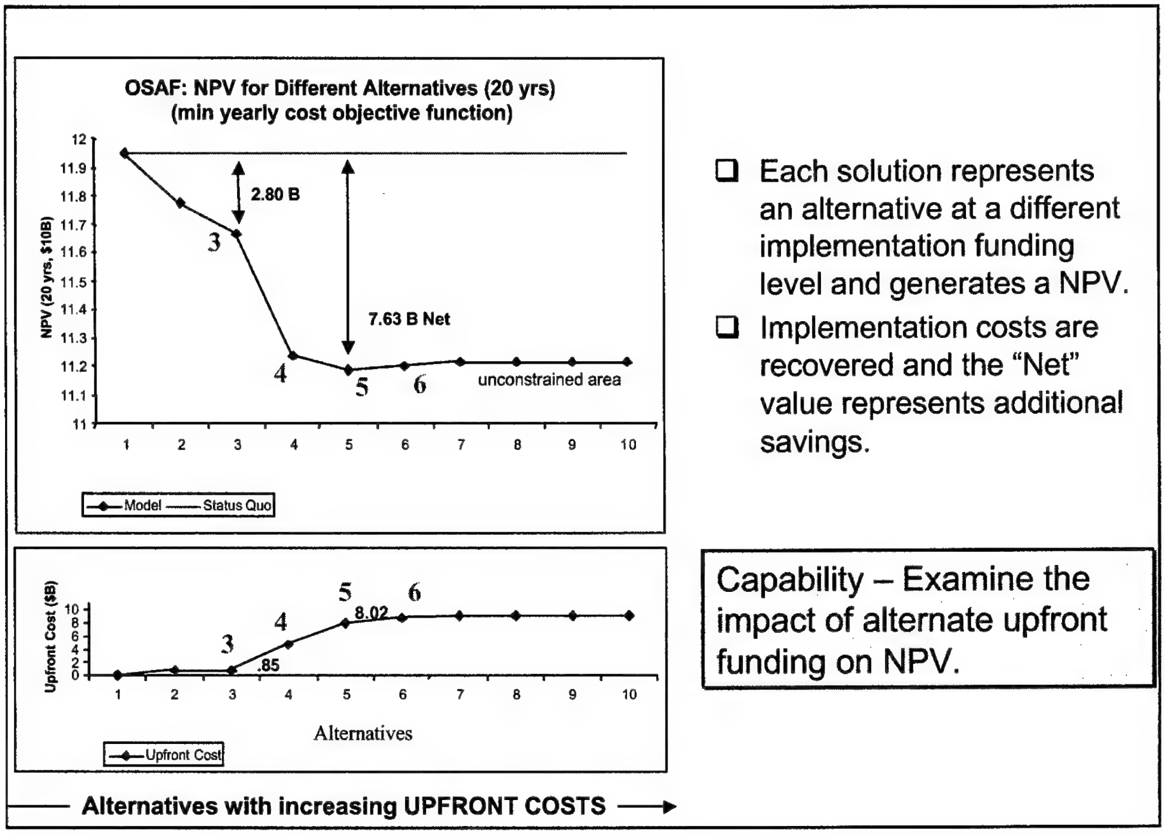


Figure 15. Evaluating Results (example)

From the figure, we see alternative #3 has a 20-year savings in NPV of approximately $2.80B, #4 ~$7.20B, #5 ~ $7.63B, and #6 ~ $7.50B. Implementation costs differ between alternatives from $850M to over $8B dollars.

We can tell from the alternatives that #5 has the best NPV, but #4 has a small degrade in NPV with about half the implementation cost. Alternative #6 has a higher NPV than #5 and uses a higher level of implementation dollars; however, the additional monies are used on moves that do not pay back in 20 years, thus the higher NPV.

The figure illustrates how we can examine alternatives at different implementation funding levels and generate both the yearly costs and NPV. It is important to note that all implementation costs are incurred during the first 6 years of a realignment action (see Appendix D). Savings are typically not realized until the outyears. If savings are based on variable cost differentials (moves), then they are slow to accrue. Savings based on fixed cost differentials (closures) accrue more quickly. In either case, all OSAF savings are net values (account for implementation costs).

4.4 Differences in Alternatives

When examining alternatives, the Army should consider all metrics. Figure 16 provides a matrix for the example alternatives in Figure 15 and how they compare within the set of metrics. The red denotes the worst case for the corresponding metric and the green denotes the best case. For

example, the "current" stationing is red for NPV because it has the highest NPV of all alternatives while alternative #6 is green for recurring costs because it has the lowest recurring cost of all alternatives.

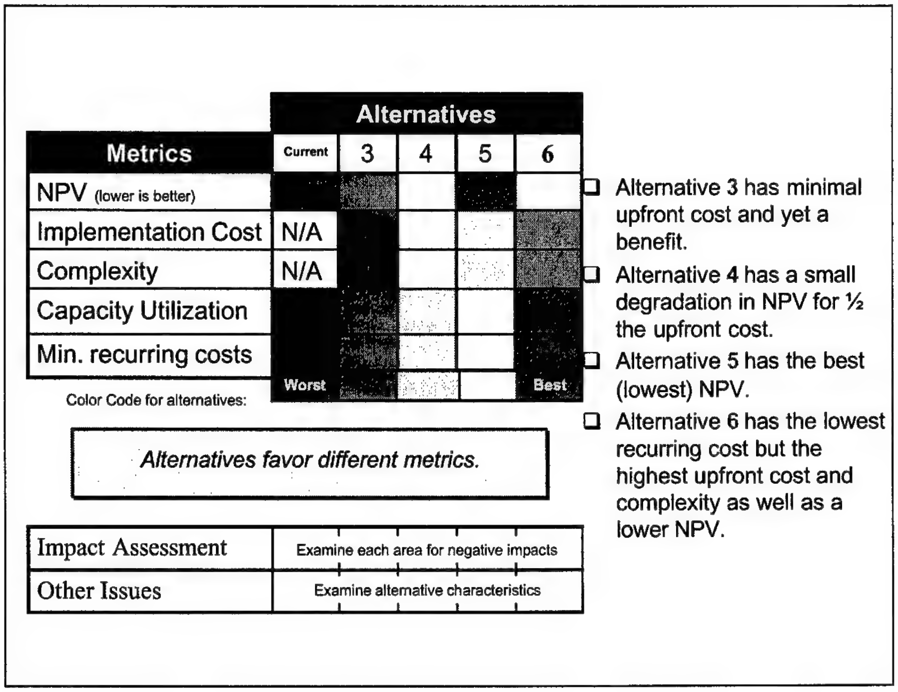


Figure 16. Differences in Alternatives

The benefit of multiple metrics is evident in the matrix; alternatives favor different metrics. If the Army's goal is to maximize utilization, then a cost is incurred in the NPV, implementation costs, and complexity metrics. If the Army wants to minimize NPV, then a cost is incurred with implementation costs and complexity (number of moves).

The metrics are objective and as such provides a valuable means to distinguish between alternatives. While the impact assessment mentioned previously is more subjective in nature it fills a niche that attempts to distinguish between alternatives for key concerns not included in the mathematical model. In addition to the metrics and the impact assessment each alternative must be examined for other issues that may make an alternative infeasible. This part of the analysis produces additional stationing restrictions.

4.5 Sensitivity Analysis

With OSAF, we can conduct sensitivity analysis to determine the impact on all metrics. Some of the sensitivities we have already considered are listed in Figure 17.

We can examine the impact on net present value, unit stationing, and installation disposition if we:

1. force one or more installations to close or stay open,
2. vary maneuver land availability,
3. use different stationing policies (e.g., BRAC 95 restrictions),
4. force "Stove Piping" restrictions on restationing and/or add restationing restrictions on individual units.

Figure 17. Example Sensitivity Analysis

1. Take the stationing alternative and from the installations that are closed--force one open. Or, from the installations that are open--force one closed. When we change an installation's disposition, then moving is impacted, and the model can tell us the cost of the action. We find that forcing one installation to stay open may or may not force another to close, but in all cases increases NPV. The same is true when we force an installation in an optimal solution to close--another installation may be forced to stay open, always raising NPV.

2. OSAF ensures that the Army maneuver land shortfall does not increase. We can increase or decrease the allowable shortage by installation or for the Army by changing a model parameter. In all cases, a relaxed maneuver land constraint allows additional moving and decreases costs. When we decrease the allowable shortage, costs increase.

3. OSAF has a limited number of stationing restrictions, which we apply to take advantage of "common sense" restrictions that could improve model performance without restricting feasible solutions. We can apply any number of restrictions (e.g., BRAC 95 restrictions) and determine the cost of the restriction. In all cases when we add a restriction, costs increase. Some restrictions can cost billions over time while others are trivial in comparison. By examining the

impact of different restrictions on alternatives, the Army will be more informed concerning the restrictions they wish to counter.

4. Although OSAF does not stove pipe, it is easy to limit possible stationing between types of installations or any group of installations. Whenever we examined the impact of stove piping, due to its restrictive nature, we found that it has negative impacts on all alternatives.

Additional information on sensitivity analysis is in Appendix O.

4.6 OSAF Parameter Insights

Initial analysis provided insights on what parameters in the model were the most influential in determining alternative stationing. Knowing the most influential parameters helps explain alternatives, enables concentrated efforts on improving data quality, and focuses modeling efforts.

We describe each of the parameters in Figure 18 in Appendix G. The figure shows that of the eight primary parameters in the model, the BOS costs have the most influence on alternatives. The variable BOS influences moving of individual units while the fixed BOS is an incentive to close an installation.

Parameter	Influence on Alternatives	Comments
Base Operating Support	[redacted]	Fixed/Variable Cost
Maneuver Land		Adjustable limits
MILCON		One Time Cost
Housing	Moderate	Variable Cost
Real Property Maintenance	Minor	Variable Cost
Ranges	Minor	Adjustable limits
Program Costs	Minor	One Time Cost
Moving	Minor	One Time Cost

Figure 18. OSAF Parameter Insights

The maneuver land requirement is also a major driver in the model owing to the availability of lands and the large requirements for some units. OSAF ensures maneuver land availability and therefore severely restricts stationing of units with a maneuver land requirement. For additional information, see Appendix K.

The most influential implementation cost is MILCON. All other implementation costs are minor when compared to MILCON, though not necessarily in a dollar sense.

Ranges are also a minor influence on moving. OSAF allows shortages to exist (they exist in status quo case) up to a certain level. Once beyond this level OSAF forces a range purchase. We find that the maneuver land requirements are binding, while the range requirements are not.

Buildable acres is an additional parameter that influences alternatives, but it is not used in OSAF. Instead we use it in preprocessing to limit new MILCON only to those installations with adequate buildable acres.

Buildable Acres			
ABERDEEN	1150	LEAVENWORTH	1814
AP HILL	30244	LEE	652
BELVOIR	1047	LEONARD WOOD	5781
BENNING	4100	LEWIS	10747
BLISS	3000	MCNAIR	2
BRAGG	1949	MCPHERSON	127
BUCHANAN	53	MEADE	3635
CAMPBELL	9000	MONROE	149
CARLISLE	32	MYER	1
CARSON	2252	POLK	3877
DRUM	10304	RICHARDSON	700
EUSTIS-STORY	603	RILEY	5930
GILLEM	220	RUCKER	5203
GORDON	4960	SAM HOUSTON	616
HAMILTON	10	SCHOFIELD	110
HOOD	10000	SHAFTER	11
HUACHUCA	1447	SILL	1850
IRWIN	1550	STEWART	30659
JACKSON	4153	WAINWRIGHT	700
KELLY	36	WEST POINT	0
KNOX	2000		
(Source: VOL II, DOA Installation Assessment, March 1995)			

Figure 19. Buildable Acres

Figure 19 lists the buildable acres on OSAF's installations. We can see from the figure that seven of the installations have less than 40 buildable acres (shaded). We exclude these from possible *new* military construction.

4.7 Risks in the Stationing Process

Risks exist in any stationing alternative and in the stationing process. Initial analysis identified some elements of risk we need to be aware of and take into account when examining alternatives.

1. Cost. Historically, the costs for moving (in past BRAC actions) have been hard to estimate and confirm [Numerous examples, e.g., GAO/NSIAD-97-151].

- **Utilities.** COBRA/URCM estimates for infrastructure do not include utility upgrades. There will be a cost incurred for the utility infrastructure required supporting new MILCON. A 10 percent figure would capture these additional costs in the short term until improved factors are developed.

- **Economic assistance (assistance to local communities provided to overcome realignment impacts).** OSAF does not consider these costs even though they may be substantial [numerous, e.g., GAO/NSIAD-96-67, p 4], primarily because we do not have the means to estimate these costs.

- **Environmental costs.** One of the largest costs DOD can face on an installation are the environmental remediation costs. We capture some of this cost risk through the potential opportunity cost of speeding up remediation, but uncertainties in these costs can make the risk much greater. The unexploded ordnance costs may be expansive. While they should not be used for stationing decisions, they could possibly accelerate due to closures. GAO states that "we have concurred with DOD not considering these costs in developing its cost and savings estimates as a basis for base closure recommendations. At the same time, we agree with DOD's position that environmental restoration costs are a liability to it regardless of its base closure decisions; and we note, these costs are substantial" [GAO/NSIAD-97-151, p 25].

- **Movement costs.** We do not include movement costs for units training at an installation other than where they're assigned. The set of units that can train other places is small and the possibilities of where they can train are all acceptable. The more important constraint is the availability of training facilities.

2. Training.

- **Estimates.** The current estimates for Army training lands are only estimates and subject to change. We should be reluctant to divest an installation with significant training lands to hedge against shortfalls especially when future Army systems may require additional training lands.

- **Training costs**. A possible training objective would be to move units to installations with lower training costs. Training costs are a function of the installation, command environment, OPTEMPO, environmental factors, local policies, and other factors. Therefore, training costs cannot be objectively associated to a specific installation and are not included as a factor in the model.

- **Training rotations.** The Army has several rotational requirements for its active forces. If we collocate groups of units that share rotation tasks, we theoretically improve support of the rotational requirement due to the ability to pull resources from both units. Although OSAF does not address the rotational support, units can be moved to improve such support and OSAF would provide the impact on facilities, training lands, and the realignment cost.

3. Environmental issues. Unfortunately, environmental factors are not always easy to represent mathematically. For example, it is difficult to model encroachment; however, we can limit new construction in areas where encroachment has been identified as a problem (encroachment in this case is pressure on the installation due to growth in the local community). Other environmental concerns, such as noise need to be considered with each alternative. Due to the character and implications of Army training one or more environmental impacts could be interpreted as a negative result in most alternatives. Since these impacts are not easily modeled, defined, or interpreted, an inherent risk is incurred with alternatives that move larger units.

5 SUMMARY

5.1 Summary of Findings

OSAF has undergone technical scrutiny to determine if the model operates correctly from a technical perspective. We will complete one additional technical review in the near future. The OSAF team, with ACSIM and ODCSOPS representatives, examined the initial results for appropriateness and conducted a "common sense" test on each move action. The stationing restrictions are the result of three of these sessions. Additional restrictions could be added to the list at Appendix J if deemed necessary.

ACSIM has certified all data sources. CAA feels the BOS data, even though it is official, should be reviewed in more detail owing to its import and the inconsistencies seen during the analysis. ACSIM has also accredited OSAF and feels it meets their requirements.

OSAF provides an analytically defendable approach to assist the Army with their stationing analysis.

- OSAF examines the consequences of multiple unit movements and takes advantage of available facilities and training lands at least cost. The model ensures all Army requirements are met at the least cost by using the resources available on a set of installations.
- OSAF can analyze unit-level stationing alternatives and the impact of restrictions on movement.
- OSAF provides capacity utilization factors for facilities, ranges, and maneuver lands and tends to improve these factors without forcing the model to do so (cost effective). The model could be used to examine the impact of forcing certain utilization rates and the cost of such a requirement.
- Using NPV analysis, OSAF demonstrates the tradeoff between up-front costs and long-term savings for different stationing alternatives. Other metrics such as the complexity of the solution, investment cost, and payback periods, can be compared among alternatives.

Figure 20 provides a synopsis of OSAF's findings.

- **OSAF substantially increases the Army's stationing analysis capabilities. Specifically, OSAF's optimization approach improves the speed, rigor, and the ability to conduct systematic sensitivity/what-if analysis, in support of Army stationing.**
- **An Army-wide stationing that considers multiple unit movements could potentially save the Army billions of dollars (net present value). Savings are not realized for many years because of the implementation costs involved.**
- **Limiting stationing alternatives to installations of the same "type" or "stove piping" can significantly decrease opportunities to save stationing dollars. For example, limiting stationing alternatives for maneuver installation units to only other maneuver installations ignores the potential efficiencies of moving these units to different types of installations.**
- **Varying maneuver land availability increases opportunities to station and supports the development of real estate acquisition strategies.**
- **OSAF seldom recommends inactivating installations with maneuver land except when units with a light maneuver requirement can use heavy training lands.**
- **OSAF prefers a smaller set of large multipurpose installations instead of smaller limited purpose installations.**
- **A cost saving unit-stationing action can trigger a complex series of additional unit moves.**
- **A stationing alternative must be evaluated using a family of metrics, both quantitative and qualitative.**

Figure 20. Summary of Findings

Past Army stationing analysis with COBRA/URCM was based on a spreadsheet type approach that took considerable time to define and examine a stationing scenario. OSAF uses an optimization approach that examines all possible alternatives for stationing given a set of assumptions and constraints. OSAF completes a model run very quickly; 2-10 minutes to examine all alternatives versus days to examine one alternative. OSAF also improves analytical completeness, provides systematic sensitivity analysis, integrates across different models, and increases flexibility (what if capabilities) of current Army stationing analytics.

A move process that systematically examines moving alternatives from an Army-wide perspective (a system of moves) could potentially save the Army billions of dollars (NPV). Savings are not realized for numerous years due to the implementation costs involved. An example of a timeline for anticipated savings is in Appendix D. Even though stationing actions do not provide short-term budget assistance, they should still be considered and possibly executed. Otherwise, 10 years from now the Army will face the same installation situation, cost issues, and the same dilemma of short- versus long-term perspective.

The clear division between installation types may be appealing; however, stove piping is the most constraining of policies and should be avoided if possible. Stove piping significantly impacts stationing opportunities (decreases potential savings by over 30 percent). Stove piping does not assist in developing efficient installations. While OSAF does not include all Army installations, Joint assets, and Reserve or National Guard properties (all forms of stove piping), additional installations could be added as target installations for units in OSAF. This action might influence the eventual stationing plan for those installations, but may also provide alternatives for OSAF units especially those not requiring maneuver lands.

We find that maneuver land is one of the most constraining requirements. By varying maneuver land availability, we can increase opportunities to station and support the development of real estate acquisition strategies. OSAF can determine what installations would provide the most benefits to the Army if additional lands at the installation are available. This ability prioritizes the search for additional lands and possibly helps ACSIM develop their strategy.

Maneuver land is an influential constraint in the model and limits moving of numerous units due to a lack of installations with enough maneuver land for larger units. Therefore, OSAF generally avoids deactivating installations with maneuver land. But allowing a light maneuver requirement to use heavy training lands allows a maneuver installation to close.

OSAF targets command and control/administrative installations for deactivation. Command and control installations tend to be administrative installations with very little, if any, maneuver land. Because of this, there is little reason to keep the installation open unless a mission related or geographical reason dictates otherwise. OSAF deactivates installations to save fixed BOS costs. It prefers a smaller number of large multipurpose installations mainly because larger installations are more efficient and tend to have more resources. By closing smaller installations with limited resources, the savings in fixed cost more than takes care of implementation costs.

A cost saving unit-moving action can trigger a complex series of additional unit moves. Moving should be viewed as a system of moves and not as individual moves. If we limit moves or groups of moves, there is a possibility that moves with poor payback that enables larger payback moves will not be considered. The payback-metric is valuable when evaluating a move that is unconnected within a system of moves.

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APPENDIX A PROJECT CONTRIBUTORS

1. PROJECT TEAM

a. Project Director

LTC William J. Tarantino, Resource Analysis Division

b. Team Members

Mr. Gary Connors

c. Other Contributors

Mr. Kevin Tomich
Ms. Kumud Mathur
Mr. Mark Ricks

2. PRODUCT REVIEWERS

Dr. Ralph E. Johnson, Quality Assurance
Ms. Nancy M. Lawrence, Publications Center

3. EXTERNAL CONTRIBUTORS

Dr. Robert Dell (Naval Postgraduate School)
Mr. Gregory Brewer (ACSIM)

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APPENDIX B REQUEST FOR ANALYTICAL SUPPORT

PART 1

Performing Division: RA *Account Number:* **2000166**

Tasking: Verbal *Mode (Contract-Yes/No):* No

Acronym: **OSAF**

Title: Optimal Stationing of Army Forces

Start Date: 09-May-00 *Estimated Completion Date:* 01-Feb-01

Requestor/Sponsor (i.e., DCSOPS): ACSIM *Sponsor Division:* DAIM-MD

Resource Estimates: *a. Estimated PSM:* 55 *b. Estimated Funds:* $0.00

c. Models to be Used: **OSAF**

Description/Abstract:

In support of the QDR Installation Sub-Panel develop and demonstrate an optimization based stationing model to station current and future Army Forces. The model or set of models will include the full spectrum of Army Forces (Active, Reserve, National Guard), facilities on Army bases, and mission requirements. This problem is a capacitated facility location problem, which is similar to past Base Realignment and Closing efforts. This effort will incorporate the QDR Stationing Model data updates for the COBRA model.

Study Director/POC Signature: ***Original Signed*** *Phone#:* 703-806-5446

Study Director/POC: **LTC William Tarantino**

If this Request is for an External Project expected to consume 6 PSM or more, Part 2 Information is Not Required. See Chap 3 of the Project Directors' Guide for preparation of a Formal Project Directive.

PART 2

Background:

The Quadrennial Defense Review (QDR) asks the overarching question, "What are the infrastructure requirements to support the Army of the future?" The ACSIM tasked CAA to develop a methodology to assist him in answering this question.

Scope:

Address five different installation types in the continental US (CONUS): maneuver, command and control, professional schools, major training areas, and training schools. Include major leased facilities, heavy and light maneuver unit requirements, ranges, facilities, and all major units currently stationed on final installations. Incorporate the National Guard and Reserve Component requirements; however, only stations active component units.

Issues:

1. Determine the optimal stationing of Army forces given the force and associated installation support requirements. 2. Provide an analytically defensible approach to examine stationing alternatives for a given Army force structure. 3. Examine Army facility utilization and determine potential improvements through stationing. Determine facility capacity factors for different stationing alternatives. 4. Determine costs and potential savings for stationing alternatives.

Milestones: Provide operational model in February 2001.

Signatures *Division Chief Signature:* ***Original Signed and Dated*** *Date:*

Division Chief Concurrence: Mr. Steven Siegel

Sponsor Signature: ***Original Signed and Dated:***

Sponsor Concurrence (COL/DA Div Chief/GO/SES): ACSIM

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APPENDIX C STUDY PLAN (JUNE 2000)

CSCA-RA

Memorandum for Director, Center for Army Analysis

Subject: Study Plan, Optimal Stationing of Army Forces (OSAF)

1. **Purpose**. This memorandum serves as the study plan for the Optimal Stationing of Army Forces (OSAF) study. It details the key concepts that form the framework for study guidance and requirements.

2. **Problem**. Conduct an analysis of optimal stationing of Army forces.

3. **Background**. ACSIM tasked CAA to analyze what installations are required to support the stationing of current and future forces.

a. The QDR Installations Panel has been tasked to determine 1) what installation capabilities are required to support the future force, and 2) what is the total cost to optimally station the future force?

b. The Army has conducted similar analysis for base realignment in the past that will provide background information for the current stationing issues.

c. The DCSOPS/VCSA/ACSIM need the ability to conduct orderly stationing planning that considers force requirements, what-if analytical capability for optimal stationing and force realignments, the ability to measure the efficiency of a solution, and a quick turnaround capability.

4. **Study Sponsor**. The Office of the Assistant Chief of Staff for Installation Management (ACSIM). Study sponsor's representative is Mr. Greg Brewer.

5. **Study Agency**. The Center for Army Analysis will lead the study, develop the analytical methodology, and conduct the analysis. R&K Engineering will provide study support through the QDR stationing model and data collection.

6. **Key Definitions**.

a. Mission Requirements: Military units, personnel, equipment, military schools, maintenance capabilities, all tenet units, and sustainment that are essential to support the current and future force.

b. Force: TOE, TDA, National Guard, and Reserve Component units.

c. Stationing: The act of assigning a mission requirement to a location (station).

d. Infrastructure: Existing buildings, ranges, maneuver areas, housing units, maintenance facilities, etc., on chosen Army bases.

e. Costs: All sustainment, upgrades for infrastructure, transportation, environmental, closing, new construction, leasing, and other possible costs.

f. Supporting Models: All other Army models that support this analysis (Appendix A).

7. **Key Objectives**.

a. Examine the installation support required for the current and objective force mission requirements.

b. Given the force and associated installation support requirements, determine the optimal stationing of Army forces.

c. Identify efficiencies and risks inherent with different possible stationing plans.

d. Determine facility capacity factors for different stationing alternatives.

8. **Scope**.

a. Time period: Conduct analysis for the period 2001 and 2010 (subject to change).

b. Forces: Active, National Guard, and Reserve Component units (units TBD). Station all active forces and consider other force requirements.

c. Locations: Attached at Appendix B.

d. Activities: major military units, military schools, major tenet units at support locations, leased facilities, and major Army command headquarters.

e. Criteria: Solutions will be evaluated based on their overall cost, the ability to fulfill stationing requirements, and the efficient utilization of resources.

9. **Key Assumptions**.

a. Required data is available, timely, and accurate.

b. If green facilities according to the Installation Status Report (ISR) are not available, then existing facilities are upgraded or new construction is provided to meet realignment requirements.

c. Major environmental cleanup costs occur regardless of closing decisions and therefore are not included. Other environmental program costs are included.

d. Past analyses are a "point of departure" for OSAF analysis. (OSAF needs to use appropriate costs, data sources, and lessons learned.)

e. The training metrics (range days, KM^2Days) in the Army Range and Training Land Program Requirements Model (ARRM) are preferred (to acre requirements) to determine and measure unit training requirements.

f. Unused training KM^2Days and range days resulting from fulfilling training requirements can be aggregated and applied to other requirements.

g. The private market can meet new housing and utility requirements.

h. If a base is deactivated, Army Reserve and Guard units remain behind in an enclave along with non-DOD tenants.

i. Facility category groups (FCGs, e.g., administrative facilities) can be aggregated into larger categories without understating requirements.

j. The smallest maneuver force realigned is the maneuver brigade.

k. National Guard and Reserve minor training sites can accommodate smaller-scale range and training requirements.

l. Low-hanging fruit has already been picked.

m. Only realign a lease to within 50 miles of its current location.

10. **Key Limitations.**

a. Problem size limits the ability to solve optimal stationing using ***all*** details regarding forces, resources, and issues. Therefore, realignments below the brigade level will not be visible.

b. National Guard elements are consolidated at the regional level.

c. The optimization recognizes savings from reduced installation support overhead, but not additional efficiencies from combining units. (Other efficiencies are possible.)

11. **Methodology**.

a. OSAF is a bi-criteria, mixed integer programming model developed to solve a capacitated facility location analysis problem with multiple supporting models. The capacitated facility location problem is commonly found in the literature; however, the particular aspects of

military stationing are not as common as civilian applications. The following applications will serve as the basis for this effort:

(1) Dell, R.F., Fletcher C., Parry, S.H., and R. E. Rosenthal, 1994, *Modeling Army Maneuver and Training Base Realignment and Closure,* Technical Report, Naval Postgraduate School, Monterey, CA.

(2) Loerch, A.G., Boland, N., Johnson, E.L., and George Nemhauser, 1996, Finding an *Optimal Stationing Policy for the US Army in Europe After the Force Drawdown*, Military Operations Research, Vol 2, No. 4.

(3) Tarantino, W.J., 1992, *Modeling Closure of Army Materiel Command Installations: A Bi-Criteria Mixed Integer Programming Approach*, Masters Thesis, Operations Research Department, Naval Postgraduate School, Monterey, CA.

b. OSAF has four primary stages: installation inventory, installation review, alternative development, and alternative evaluations.

c. Data requirements and sources are attached at Appendix C (as of 08/24/00).

d. The optimization model:

(1) Objectives: minimize overall stationing costs.

(2) Subject to:

i. The availability of maneuver area and training ranges (training days),
ii. Facility availability and condition (ISR),
iii. Force requirements, and
iv. Budget constraints.

e. The baseline analysis will include:

(1) The current stationing of Army forces on selected installations and the associated shortfalls in selected facility categories and training assets, capacity utilization rates, mobilization infrastructure, and facility conditions. (Further analysis will be possible when force structures are available.)

(2) Determine the optimal location to add one maneuver brigade to the force structure.

(3) Determine the optimal location to take one maneuver brigade from the force structure.

(4) Examine the stationing of leases while maintaining all force structure at current stations.

12. **Responsibilities.**

a. CAA

(1) Provide overall supervision of the OSAF study, to include providing the study director, conducting interim and final briefings, publishing a final report, and supporting the sponsor at appropriate professional meetings and functions.

(2) Provide expertise for optimization models.

b. ACSIM

(1) Study sponsor.

(2) Provide access to data and supporting models.

c. SSMI Sub-Panel: Provide guidance and force structure for analysis.

d. The QDR office will provide required funding.

13. **Administration.**

a. The study sponsor must request exceptions to this study plan.

b. Milestones

Data collection and development	Ongoing
Initial ARB	10 August 2000
IPR	As required
Data finalized for base case	15 Sept 2000
Data Approved	30 Sept 2000
Prototype model	November 2000
Base case analysis produced	February 2000
Final ARB	TBD

c. This study directive complies with the mission, functions, and procedures of CAA and has been developed in coordination with ACSIM.

WILLIAM J. TARANTINO
LTC, Project Director (OSAF)
CAA, RA Division

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APPENDIX D CASH FLOW ANALYSIS

D.1 Minimize Stationing Cash Flow

Overview. OSAF includes the recurring and implementation costs (one-time costs) shown in Figure D-1 and applies appropriate present value weights on cost categories. Using the time value of money, OSAF computes present value (PV) factors for each cost and uses these PV factors to weight costs. By doing this, OSAF minimizes the present value of the stationing cash flow for all OSAF installations.

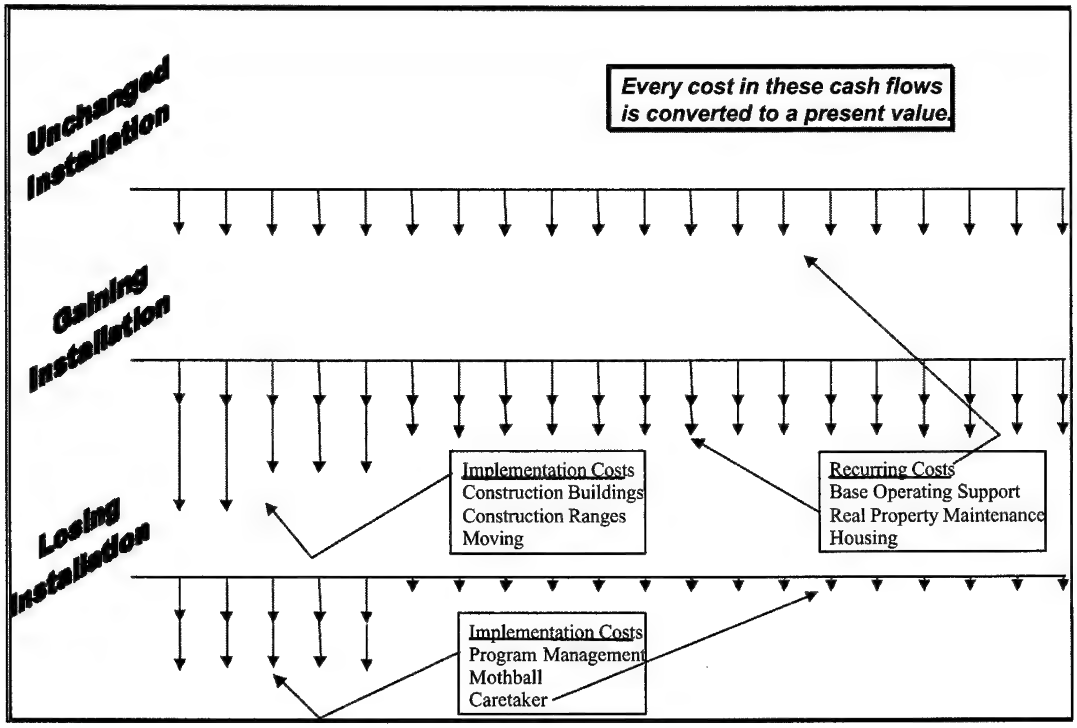


Figure D-1. Minimize Stationing Cash Flow

Figure D-1 has three "cash flows", which represent 20 years of costs for an installation. For example, the top cash flow has 20 years of costs based on a status quo stationing where the installation has no movement on or off the installation; each year has the same cost. The second cash flow represents an installation that gains units. The installation has additional implementation costs in the first 5 years followed by 15 years of higher operating costs. The third cash flow represents losing installations, which also have 5 years of implementation costs, but now have 15 years of lower operating costs.

OSAF determines the cash flow for each installation and minimizes the overall NPV.
A difficulty with computing PV factors for cost categories lies in determining when these costs occur. The OSAF team examined 53 COBRA scenarios and excursions used in the BRAC 95

process. These 53 scenarios were chosen from a set of 623 scenarios because they involved installations that were in the OSAF installation types (i.e., maneuver, training areas, etc.) (see Table D-1). After examining the costs for the 53 scenarios, we obtained an expected cash flow profile for cost categories and computed the PV factors.

We use OMB Circular A-94, Appendix C (as revised in January 2000) discount rate of 4.1 percent. It is a real discount rate that is appropriate for a constant dollar analysis (FY 2001 dollars) involving the cost effectiveness of an internal government investment. The discount rate is a scalar in OSAF and is changed as the circular updates.

D.2 Adjusted Present Value Factors (MILCON Example)

The MILCON Example. For the 53 subject scenarios, we identified $4,225M of MILCON. These costs were spread from years 1 to 5 as shown in Figure D-2. By taking the cost spread on a percentage basis and multiplying each year's percent by the corresponding PV factor, we can compute an adjusted PV (APV) for each year. When we sum the APVs for all years, the result is an APV (0.935), which can be applied to MILCON. This results in a PV for MILCON across the 53 scenarios of $3,950 ($4,225M * 0.935). This is the same result as multiplying the MILCON cost for each year by the corresponding PV factor and summing the result (i.e., $361M * 0.980 + $2,823M * 0.942 + etc.).

MILCON Example

- Examined MILCON cost from 53 COBRA scenarios ($4,225M).
- Determined the distribution of MILCON from the scenarios.
- Calculated present value factors at 4.1% (real discount rate from OMB Circular A -94).
- Calculated Adjusted PV Factors.

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
MILCON ($M)	361	2,823	978	31	31	4,225
% MILCON by year	8.6%	66.8%	23.2%	0.7%	0.7%	100.0%
PV Factor @ 4.1%	0.980	0.942	0.904	0.869	0.835	
Adjusted PV Factor	0.084	0.629	0.209	0.006	0.006	0.935

Figure D-2. Adjusted Present Value Factors

D.3 Adjusted Present Value Factors (Implementation Cost Example)

Implementation Costs. The table in Figure D-3 shows the APVs for implementation cost categories. Except for caretaker cost, the APVs for these costs are based on the same technique described in the MILCON example.

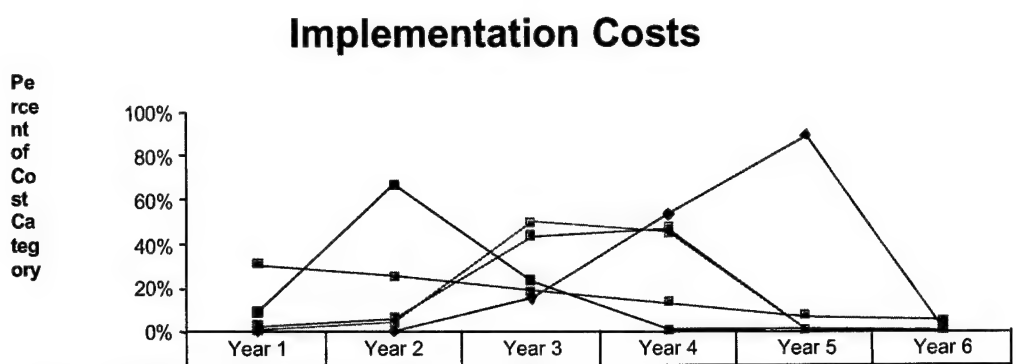
Implementation Costs

	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Total
PV Factor @ 4.1%	0.980	0.942	0.904	0.869	0.835	0.802	
MILCON ($M)	361	2,823	978	31	31	0	4,225
% by Year	8.6%	66.8%	23.2%	0.7%	0.7%	0.0%	100.0%
Adjusted PV Factor	0.084	0.629	0.209	0.006	0.006	0.000	0.935
Moving ($M)	7	37	487	444	0	0	975
% by Year	0.7%	3.8%	50.0%	45.5%	0.0%	0.0%	100.0%
Adjusted PV Factor	0.007	0.036	0.452	0.395	0.000	0.000	0.890
Program Mgt ($M)	140	117	85	60	32	22	456
% by Year	30.6%	25.6%	18.7%	13.1%	7.1%	4.9%	100.0%
Adjusted PV Factor	0.300	0.241	0.169	0.114	0.059	0.039	0.922
Mothball ($M)	12	28	199	215	0	0	454
% by Year	2.7%	6.2%	43.8%	47.3%	0.0%	0.0%	100.0%
Adjusted PV Factor	0.027	0.058	0.396	0.411	0.000	0.000	0.892
SPECIAL CASE	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6 -20	Steady State
Caretaker ($M)	0	0	9	31	52	59	59
Cumulative %	0.0%	0.0%	15.0%	53.4%	88.7%	100.0%	
PV Factor @ 4.1%	0.980	0.942	0.904	0.869	0.835	9.215	
Adjusted PV Factor	0.000	0.000	0.136	0.464	0.741	9.215	10.555

Figure D-3. Adjusted Present Value Factors

Caretaker cost is the recurring cost required to provide minimal operations and security for a deactivated installation. The recurring nature of caretaker cost demands that it be treated differently. For the first 5 years, caretaker is treated in the same way as other implementation costs; we sum the APV factors of .136, .464, and .741 (equaling 1.341). By year 6, caretaker reaches a steady state level and recurs for every year thereafter. The PV factor for years 6 through 20 is 9.215. When we add this value to the APV for years 1-5, we have the caretaker APV for years 1-20, 10.555.

Figure D-4 illustrates the dispersion of the implementation costs over the first 6 years of a stationing action. All costs except for the caretaker category are assumed completed in year 6 (completion based on historical analysis; caretaker continues until year 20).



	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
MILCON	8.6%	66.8%	23.2%	0.7%	0.7%	0.0%
MOVING	0.7%	3.8%	50.0%	45.5%	0.0%	0.0%
Pr. Mgt.	30.6%	25.6%	18.7%	13.1%	7.1%	4.9%
Mothball	2.7%	6.2%	43.8%	47.3%	0.0%	0.0%
Caretaker	0.0%	0.0%	15.0%	38.4%	35.3%	0.6%*

MILCON — MOVING — Pr. Mgt. — Mothball — Caretaker

* costs are in year 6-20

Figure D-4. Expected Implementation Costs

The values in Figure D-4, represent the percentage of the total stationing cost broken down by implementation cost type in the year that we expect them to occur. The main cost driver is MILCON, which is historically completed in year four (others include moving, program management, mothball, and caretaker costs). The MILCON allows some movement to take place prior to realignment completion; however, a stationing action is not completed until year 5, when movement costs are completed. This being the case, any stationing action's implementation costs should be considered payable in the first 5 years and are not recouped with accumulated savings until the unit completes movement in year 6. OSAF assumes that possible savings from a unit's move occur at the same rate as movement lagged by 1 year.

D.4 Adjusted Present Value Factors (Recurring Cost Example)

Recurring Costs (BOS, ROM, Housing)

There are two levels of recurring costs for each installation, the status quo level of cost under current stationing and the steady state level after restationing has occurred. The status quo and the steady state levels are equivalent at an installation with no restationing actions. If the installation has gained units, the steady state is higher than the status quo and, if the installation has lost units, the steady state is lower.

Recurring Costs (BOS, RPM, Housing)

- Two levels of recurring cost:
  - Status quo – Recurring costs prior to a unit move.
  - Steady state – Recurring costs after all moves for a unit are complete.
- Assume steady state costs phase in with moving costs with a one year lag. Status quo phases out by the same increment.

	1	2	3	4	5	6
Moving Costs, Cumulative %	0.70%	4.48%	54.47%	99.97%	100.00%	100.00%
% of Steady State Cost by Year	0.00%	0.70%	4.48%	54.47%	99.97%	100.00%
% of Status Quo Cost by Year	100.00%	99.30%	95.52%	45.53%	0.03%	0.00%
Discount Factors	0.9801	0.9415	0.9044	0.8688	0.8346	0.8017
Status Quo Discount Factor	0.9801	0.9350	0.8639	0.3956	0.0003	0.0000
Steady State Discount Factor	0.0000	0.0066	0.0405	0.4732	0.8343	0.8017

Sum Years 1-5:
3.175 Status Quo
1.355 Steady State

- Steady state prevails for years 6-20. PV Factor for years 6-20 is 9.215.
- Therefore:

P(Total) = R(Status Quo) * 3.175 + R(Steady State) * 10.570
P(Total) = PV of recurring costs for years 1 – 20.

Figure D-5. Adjusted Present Value Factors

OSAF assumes that steady state costs phase in with moving costs with a 1-year lag, and status quo phases out at the same rate. Figure D-5 shows adjusted discount factors for status quo and steady state cost given these assumptions.

D.5 PV Net Savings Metric

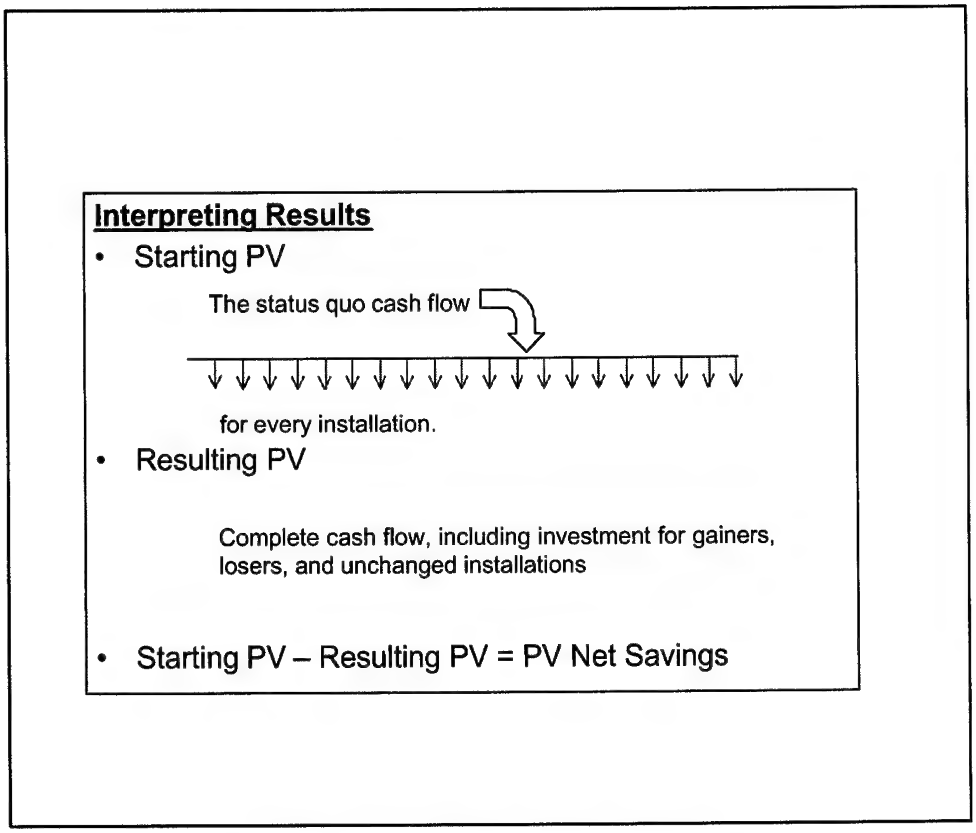


Figure D-6. PV Net Savings Metric

PV Net Saving Metric – Interpreting Results

As shown in Figure D-6, PV net savings is the result of subtracting the resulting PV from the starting PV. Since the resulting PV includes investment costs, this means the investment has already been "netted out" of the PV savings. If an OSAF solution requires \$1B in investment, and the resulting PV Net Savings is \$4B, the \$4B in savings is the amount remaining after the PV of the \$1B investment has been offset by gross savings after time value of money considerations.

D.6 COBRA Scenarios

The following COBRA scenarios from BRAC 95 provided the information on projected costs used in this appendix. The scenario cash flows provide a common basis for cost estimates for all Services (the scenarios are not historical cash flows).

Table D-1. COBRA Models BRAC 95

SCENARIOS USED TO MODEL CASH FLOW

Scenario no.	Description
A1-1X10	*Move Ft. Monmouth to Ft. Jackson*
A3 - 6	*Ft. Belvoir, Ft. Meade*
A7-2X1	*Ft. Drum*
CA11-2K1	*Close Ft. Ritchie, Move to Ft. Detrick, Ft. Huachuca*
CA11-2QX	*Close Ft. Ritchie, Relocate to Ft. Detrick*
CA11-2R	*Close Ft. Ritchie, Relocate to Ft. Huachuca*
CA-13A	*Close Ft. Totten, Relocating to Ft. Hamilton*
CA15-1QX	*Close Selfridge*
CA1-6	*Kelly Support Center: Reserve command to Ft. Meade, Relocating to Ft. Drum*
CA1-8	*Enclaving of Kelly Support Center, Relocate the portion of Ft. Drum*
CA4-1	*Realignment of Ft. Buchanan*
CA4-2B	*Ft. Buchanan to Ft Meade, Ft Drum, Ft Indiantown Gap, Lease space*
CA6-4	*Close Ft. Hamilton and Relocating to FT. Dix*
JM4-1P	*Transfer 85-90% catchment of Ft. Meade area to Walter Reed.*
JM4-1q	*Transfer Ft. Meade to Walter Reed AMC*
MA7-1	*Close Ft. Richardson and move to Ft. Wrainwright*
MA7-3-1	*Close Ft. Richardson and move to Ft. Wrainwright*
MD1-8QAX	*Fitzsimmons AMC to Sam Houston, Carson, Gordon, Shafter, Sam Houston, Walter Reed, Lewis*
MI13-1	*Close Sudbury Training, Relocate tenant units.*
MI14-1	*Close Hingham*
MI18-1	*Camp Bonneville to Ft Meade, Ft Drum, Ft Indiantown Gap, Lease space*
MI2-1	*Close Rio Vista*
MI3-1	*Close Bellmore Logistics*
MI4-1	*Close Sievers Sandberg*
MI5-1	*Close Camp Kilmer*
MI6-1	*Close Ft. Missoula*
MI8-1	*Close Camp Bonneville*
TE1-3	*NAWC Pax River to Bliss , Carson, Gordon, Shafter, Rucker, Walter Reed, Lewis*
TS10-1	*Close Ft. McClellan, OSUT to Ft. L' Wood, Realign to Ft. L'Wood, Jackson, Sills, Knox.*
TS10-1-1	*Close Ft. McClellan, Realign to Ft. L' Wood, Jackson and Rucker.*
TS10-1A	*Close Ft. McClellan, Realign to Ft. L' Wood, Rucker, Jackson*
TS10-1C	*Close Ft. McClellan, Realign to Ft. L' Wood, Jackson, Sill, and Knox*
TS10-1C1	*Close FT. McClellan and realign Ft Leonard Wood to Ft. Jackson, Sill and Knox*
TS10-1X1	*Close Ft. McClellan realign to Ft. L' Wood*
TS1-1	*Close Ft. Eustis, Move to Ft. Lee, Ft. Rucker, Realign to Ft. L' Worth and Ft. Monroe.*
TS1-2	*Close Ft. Eustis, Move to Ft. Lee, Realign to Ft. Lewis, Ft. Rucker*
TS13-1	*Close Ft. Sill, realign to Ft. Bliss, Knox, Jackson and L' Wood*
TS14-1	*NAWC Pax River to Bliss , Carson, Gordon, Shafter, Rucker, Walter Reed, Lewis*
TS2-1X1	*Close Ft. Lee, Move CASCOM HQ to Ft. Eustis, Realign to Ft. Rucker, Ft. Monroe*
TS2-5	*Close Ft. Bliss, Realign to Sill, Move to Knox, Ft. Leavenworth, And Rebuild at Ft. Huachuca*
TS2-5X1	*Close Ft. Bliss, Realign to Sill, Move to Knox, Ft. Leavenworth, And Rebuild at Ft. Huachuca*
TS3-1	*Close Ft.Eustis, Move to Ft. Lee, Ft. Rucker, Realign to Ft. Leavenworth and Ft. Monroe*
TS3-1A	*Close Ft.Eustis, Move to Ft. Lee, Ft. Rucker, Realign to Ft. Leavenworth and Ft. Monroe*
TS3-1MC	*Close Ft. McClellan, realign and move to Ft. L' Wood and realign from Ft. L' Wood to Ft. Sill and Knox*
TS3-1X1	*Close Ft. McClellan, Realign and move to Ft. L' Wood, Jackson and realign from Ft. L' Wood to Ft. Sill and Knox*
TS3-2	*Close Ft. Eustis, move to Ft. Lee, L' Worth and portion of to Monroe, realign to Ft. Lewis and Ft. Rucker.*

TS3-2LW	***Close Ft. Leonard Wood, realign to Ft. McClellan, Sill and Knox***
TS3-2X1	***Close Ft. Leonard Wood realign to Ft. McClellan, Ft. Sill, Knox and Jackson.***
TS4-1MON	***Close Ft. Monroe, Move TRADOC to Ft. Eustis and realign to Ft. Rucker***
S5-1POM	***Move POM to Ft. Huachuca***
TS8-1XX	***Close Ft. Lee. Move to Ft. Eustis, realign to Ft. Monroe Rucker.***
TS8-1XX1	***Close Ft. Lee, Move to Ft. Eustis, realign to Ft. Monroe.***
TS9-1-1	***Close Ft. L' Wood, Realign to Ft. McClellan, Ft. Sill, Knox and Jackson.***

APPENDIX E ENVIRONMENTAL FACTORS TO CONSIDER PRIOR TO RESTATIONING FORCES

The environmental factors list originates from two data sources--the Environmental Regulatory Climate Model (Section 1) and the Risks to Military Land Uses Due to Exogenous Effects Report (Draft) (Section 2).

We use these factors in our impact assessment to determine if an alternative has the potential to increase environmental concerns at an installation. Further work is being done in this area (US Army Corps of Engineers (USACE), Army Environmental Center (AEC), ACSIM), which should assist impact assessments in future stationing analyses.

E.1 Environmental Regulatory Climate Model (ERCM)

ERCM is a model that supports the Installation Training Capacity (ITC), a process for assessing Army installation capability to support live training. AEC is the proponent for ERCM, Aberdeen Proving Ground, Maryland.

The environmental factors included in Figure E-1 were compiled from an ERCM run dated 8/6/97 along with updates resulting from in-process reviews (IPRs). Even though the ERCM methodology and scoring system is undergoing revision and development, the enclosed information does provide possible insights, highlight environmental factors we consider, and should be updated when AEC publishes future reports.

ERCM is a component of the ITC that assesses environmental and demographic issues. ERCM does **not** preclude making stationing decisions on an installation; rather, it provides information to assist with impact assessments.

Environmental factors categories and the subcategory definitions follow [ERCM Methodology, Final Draft, 1 Feb. 2001]; we also provide an assessment of possible impacts on restationing.

E.1.1 Cultural Resources

Subcategories

- **Integrated Cultural Resources Management Plan -** Evidences that an installation has delineated a process and priorities to manage their cultural resources and has integrated those responsibilities with natural resources management, the trainers, and other installation activities. Reduces potential for conflict with installation actions and for overlooking compliance responsibilities. DOD Measure of Merit (MOM).

- **Planning Level Surveys -** Includes existing data review, a predictive model of site location potential and historic contexts, which aid in determinations of eligibility for installations" cultural resources. An installation with significant progress on the planning level surveys will be well positioned to minimize conflicts between cultural resources compliance and installation activities. DOD MOM.

- **Programmatic Agreement** - Indicates a streamlined compliance process with the external regulatory agency, reducing the time and consultation needed prior to Commander authorizing installation activity.

- **Native American Consultation** - Identifies installations that have current training impacts due to Native American tribes/Native Hawaiian organizations.

Possible Impact on Restationing. Cultural resource management should be a manageable function that would not impede installation-restationing activities. TRADOC is rated high in terms of the "Planning Level Surveys," whereas two FORSCOM sites (Campbell and Bragg) are low for this subcategory. USARPAC sites are all low, and all but Aberdeen Proving Ground are low for AMC.

E.1.2 Natural Resources

Subcategories

- **Planning Level Surveys (PLS) and Endangered Species Management Plans (ESMPs)** – Completed PLS and ESMPs demonstrate to the regulators that the installation staff is aware of threatened and endangered species (T&E) on the installation and are proactively managing for these species. Additionally, ESMPs must be approved by Fish and Wildlife Service (FWS), thus the installation has an opportunity to build a good relationship with the regulator. PLS, in some cases, may have also been done by the FWS, adding to the confidence the regulator has in the installation's knowledge of T&E. Completed PLS and ESMPs also provide the installation with the ability to better judge whether the addition of a particular type of unit can be supported.

- **Integrated Natural Resource Management Plan** – Demonstrate to the regulators that the installation staff has integrated natural resources conservation with the mission activities and requirements. An INRMP uses an ecosystem management approach that considers effects of Army actions beyond the installation boundaries. An INRMP can only be finalized after it has been coordinated with the US Fish and Wildlife Service and the appropriate State wildlife agency, and has gone through the public comment process under NEPA. An implemented INRMP will aid the installation in land management decisions, including those pertaining to any planned military actions.

- **Jeopardy Biological Opinions (JBOs)** – The presence of JBOs indicate that there have been conflicts between T&E species and training. This is an indicator that future problems may be more likely to occur. JBOs also may indicate an adversarial relationship between the installation and the regulator. If there were a good relationship between the two parties, frequent communication on an informal basis would likely find resolution to conflicts, minimizing JBOs.

- **Negative Impact to Mission (significance factor)**[1] - Current T&ES Management and wetlands issues restricting training/testing and/or access to critical training/testing areas and facilities increase the likelihood of future negative impacts. Regulators are aware of this and will be more interested in activities on those installations.

Possible Impact on Restationing: Since the first three subcategories below are planning-related, we expect the problems in these areas are correctable. The presence of a low score in the fourth category (JBOs) indicates serious problems, serious enough that in every instance of a low score, the following block (Negative Impact to Mission) is also low; therefore, we focus on the "Negative Impact to Mission" subcategory, which has been labeled as a "significance factor." FORSCOM has a higher percentage of its installations with low scores than the other MACOMs listed on the worksheet--much higher than TRADOC; its peer in terms of size and magnitude of operations. It is possible that unit-level training has a far greater impact on natural resources than the individual training that occurs at TRADOC installations. If that were the case, it would be a functional issue and not a problem that could be solved through restationing.

E.1.3 Air Quality

Subcategories

- **Operating Within a PM_{10} (Particular Matter) Nonattainment Zone** – Vehicles traveling off road stir up enormous clouds of dust. These dust clouds can violate the air standards at points up to 8 miles from the training exercise. Calculations were based on vehicle size and use data provided by the Army training center, air emissions factors from AP-42, and use of USEPA's TSCREEN model. A heavy brigade is estimated to emit 3,288.24 tons of particulate matter per year, while a light brigade would emit 233.73 tons per year.

- **Operating Within a Severe or Extreme Ozone (03) Nonattainment Area** – Regulators could severely restrict the new brigade's training activities if they believe these activities will prevent attainment with ambient air quality standards for ozone. Restrictions may include prohibitions from training on hot and sunny days; limits on total training activities, or requirement to install pollution control equipment and purchase emissions reductions credits. Cost of equipment or reduction credits could be several hundred thousand dollars per year. Location in a severe or extreme ozone nonattainment areas is not expected to reduce training as much as being located in a PM_{10} nonattainment area as it appears that with lots of money and willingness to restrict training to certain times of the year, the brigade could accomplish at least part of their training. Regulators would be required to determine the new brigade's impact on the area's ability to eventually attain ozone air quality standards as the new brigade exceeds the threshold for a significant new source of air pollutants. The significance threshold for air emissions from a new source is 15 tons of pollutants contributing to the formation ground level ozone. These pollutants are oxides of nitrogen (Nox) and volatile organic carbons (VOCs). A heavy brigade would emit an estimated 193 tons per year of Nox and 53 tons per year of VOCs.

[1] This is a significance factor that can impact the total score. If an installation's ISR response is RED, the total score is decremented 100 percent.

A light brigade would emit an estimated 49 tons per year of Nox and 20.5 tons per year of VOCs.

- **Operating Within a Predicted $PM_{2.5}$, Nonattainment Zone** – There are two reasons for considering being located in a potential $PM_{2.5}$ nonattainment zone as somewhat less of a problem than being located in a current PMIO nonattainment zone. First, if the brigade is relocated before USEPA and the States establish $PM_{2.5}$ nonattainment zones, then they will not be required to include a $PM_{2.5}$, impact analysis as part of their new source review. It may be 5 to 7 years before USEPA and the States determine the locations $PM_{2.5}$ nonattainment zones. Second, USEPA has determined the locations of possible $PM_{2.5}$ nonattainment zones based on circumstantial data. The locations of the actual zones will not be known until the agency has had time to collect actual monitoring data. Installations located in potential $PM_{2.5}$ nonattainment zones may not be located in the actual zones.

- **Located in an area Predicted to be Out of Attainment With the Proposed Ozone Standards** – A new brigade operating in such an area may be required to limit training to cooler or overcast days. However, new regulations for the new standards are expected to affect mainly larger industrial operations. These include commercial electrical generators and chemical processing facilities. AEC believes that any proposed regulations have only a small chance of restricting a brigade's training activities.

- **Current PM Issue** – Regulators will probably not allow additional PM generating activities at an installation whose current or currently proposed activities already cause violations of the PM standards.

- **Current Title V Permit Restrictions Limiting Training** – Installations whose current Title V permit already restricts training may not be able to negotiate a new permit that allows them to increase emissions sufficiently to allow the new brigade's training.

Possible Impact on Restationing: Under "Air Quality," many installations are having trouble meeting the "O3 Proposed" standard, but according to AEC, "any proposed regulations have only a small chance of restricting a brigade's training activities." Of a more serious nature is the "Current PM Issue" subcategory. For example, the Army has two installations experiencing difficulty meeting this standard. Regulators would probably not allow additional PM generating activities at Fort Leonard Wood and Fort Bliss until current and proposed PM issues are resolved. Working to resolve such issues has the effect of limiting restationing options.

E.1.4 Water Quality

Subcategories

- **Do any high quality or scenic and wild rivers flow through, or are affected by activities on, the installation?** State and Federal regulations ban all activities that may harm these bodies of water. The Army Regional Environmental Offices identified all bodies of water at the Phase I installations and worked with State regulators to determine designated uses of these bodies of water.

• **Is the installation currently limited in the amount of water that it can draw from local water supplies?** The installation can only increase its population if it can increase its water usage. Installations whose water usage is capped at current levels cannot grow.

• **Does installation possibly impact ground water?** Regulators are reluctant to allow additional activities in areas that currently impact ground water. Additionally, municipalities and businesses that draw water from such an installation with a ***sole source aquifer*** may object to activities that may harm their water supply.

• **Has the installation incurred any notices of violation (NOVs) for sedimentation?** Pending drinking water regulations require additional protection for drinking water quality water bodies. Installations that have trouble preventing sedimentation under current regulations may be required to restrict training near water bodies by these pending regulations.

Possible Impact on Restationing: The two Arizona facilities--Yuma Proving Grounds and Fort Huachuca--are limited in the amount of water they can draw from local water supplies, limiting their growth potential. Fort Polk and Fort Lewis are limited based on their reliance on a sole source aquifer and could meet with public objections on adding activities that could possibly pollute the local water supply.

E.1.5 Noise

Subcategories

• **Noise Complaints** – Number levels at or below 65 decibels. The Army evaluates the impact of noise that may be produced by ongoing and proposed Army actions/activities and ***minimizes impacts and annoyance*** to the greatest extent practicable.

• **Number of noise related claims/lawsuits** – Installations facing noise-related claims or lawsuits are most likely facing the negative consequences of restricted actions and damaged community relations described previously. Siting a new noise generating activity on such an installation would only worsen the situation. Installations that have faced lawsuits in the past, regardless of outcome, are likely to be in sensitive areas with regards to noise. It is prudent to avoid future lawsuits by simply keeping major noise generating activities away from such installations whenever possible.

• **Management Issues Restricting Training (significance factor)** – Current noise management issues restricting training/testing increase the likelihood of future negative impacts. Regulators are aware of this and will be more interested in activities on those installations.

Possible Impact on Restationing: Fort Hood would seem to be restricted from accepting additional forces (requiring training) that would add to the unacceptable noise level problems they have been experiencing. A study of the effects additional training would have on the noise levels at Forts Campbell, Riley, and Stewart would be advisable in the event that this could

possibly push these sites into a low score regarding the Management Issues Restricting Training subcategory.

E.1.6 Contaminated Sites

Subcategories

- **Contaminated Ground Water Detected** – The regulators would not want any additional use of ground water especially if contamination has been detected on site and remediation has been proposed. The regulators concerns would be similar to the US Army Surgeon General regarding protection of human health.

- **Number of Installation Restoration Program (IRP) Sites** – If there were a large number of sites which are being investigated or remediated, the regulators would be concerned about human exposure to contaminants and the potential to spread contamination through troop activities or training.

- **National Priorities List (NPL) Status** – A Federal Facility Agreement may be in place, which could limit access to a number of areas. The regulators may be concerned about troops using areas, which are off limits. In addition, monitoring wells could also be located in these areas, which could be damaged by training activities.

Possible Impact on Restationing: Fort Lewis is the only site with contaminated ground water and a sole source aquifer. If the contaminated ground water does not pose a threat to its sole source aquifer and/or Lewis has other sources of water, then a restriction on additional forces may not be necessary. The fact that most of the ERCM installations have this problem and still operate suggests a mitigation of their groundwater problems. Most installations are coming under the "Installation Restoration Program." Although a widespread condition, caution should be taken prior to restationing forces to IRP sites to avoid the possibility of pushing more sites onto the National Priorities List, i.e., Forts Drum, Riley, Lewis, Benning, and Richardson; Schofield Barracks and Aberdeen Proving Ground.

E.1.7 Public Relations

Categories within Public Relations

Enforcement Climate is derived from the number of enforcement actions and assessed fines and penalties regarding the Safe Drinking Water Act, Clean Air Act, Hazardous Waste Management, Solid Waste Management, Solid Waste Management, and Storage Tank Management.

Public Interest Climate – Has a Restoration Advisory Board (RAB) and/or Technical Review Committee (TRC) been established? If so, have environmental concerns been raised to these bodies by the local community? Enforcement action(s)s by the community and no RAB or TRC to address these matters is the worst case.

Environmental Justice/Environmental Impact Analysis – Installation is currently identified as an area with environmental justice concerns or the target of an administrative action or lawsuit claiming disproportionate or cumulative adverse environmental or human health impacts on low income or minority communities. The USEPA Office of Enforcement and Compliance Assurance (OECA) and installation and MACOM JAG offices may provide data on environmental justice concerns and complaints.

Possible Impact on Restationing:

We cover the below three categories as though they were one, since they are closely related (public relations). It may be helpful to view the problems associated with these categories as manifestations of environmental problems, causes of which have been discussed previously. If the causes of these problems are corrected at the source, then problems with these three categories will likely be reduced, but probably never eliminated.

FORSCOM and USARPAC have low public relations and legal scores. That these installations train in unit configurations may be the variable that causes the most disruptions to local communities and surrounding environs. AMC has a particular problem with the enforcement climate subcategory, which may be related to the mission of proving grounds and missile ranges, given the environmental history of Aberdeen Proving Grounds (APG). Curiously, APG ranks highest among the four AMC installations in "enforcement climate." This may be an outcome of earlier lessons learned. The three Alaskan installations are involved in legal problems associated with the Environmental Justice/Impact Analysis subcategory. This may be a result of heightened sensitivity to these types of issues in Alaska.

E.1.8 Land Withdrawals

Subcategories

- **Pending Withdrawal Renewal (BLM)** – Installations with significant acreage due for withdrawal or permit renewal within the next 5 years are likely to have an involved National Environmental Policy Act (NEPA) requirement. The NEPA process intensifies public scrutiny of, and other agency involvement in, installation activities, both of which are not risk-free.

- **Special Use Permits Due (FS)** – An installation with a special use on a national forest should anticipate participating in the planning process and related NEPA activity for that forest plan. All special use permit renewals are accompanied with an environmental assessment that tiers from the Forest Plan.

Possible Impact on Restationing: In view of the problems Fort Bliss is having with public relations, enforcement climate, and legal entanglements, it appears to be at the greatest risk of losing the ability to accept additional forces. To a lesser extent this is true for Forts Wainwright and Greely in Alaska. Forts Polk and Benning have possible issues in their attempt to continue using national forests as part of their training regimen.

E.2 Risks to Military Land Uses Due to Exogenous Effects Report (Draft)

The US Army Construction Engineering Lab (CERL), in cooperation with the Geographic Modeling Systems Lab, University of Illinois at Urbana-Champaign, developed the "Risks to Military Land Uses Due to Exogenous Effects Report (Draft)." The Report provides additional views on environmental risk factors that could influence Army stationing. (This is also a draft product and should be considered in impact analysis when completed.)

Population Growth by Counties of Residence and Risk: The draft report by CERL is an intricate analysis of what puts an installation "at risk" due to exogenous effects related to surrounding communities. Population growth by itself may not be a cause for concern unless it combines with other "stressors" such as "income growth" and "urban development." When combined, these factors could heighten the incidences of installation-community conflict. "Risk" is a combined score (high, moderate, low) of risk factors coming under the major headings of community size, economic strength, urban area proximity, and DOD military employment. Population growth is a component of "economic strength."

CERL rankings (H, M, L) are not related to the ERCM rankings.

Possible Impact on Restationing:

In evaluating these factors, Fort Carson is possibly the riskiest installation for receiving additional forces. Their overall risk ranking of "M" includes a recent upswing in population growth (maybe the most influential catalyst for other environmental problems in the ERCM rating scheme). Aberdeen Proving Ground is also rated as an "M," but population growth did not contribute to this ranking.

Fort Belvoir ranked as a "High Risk" installation, but this could be viewed with some skepticism since Belvoir is largely an administrative post with few environmentally objectionable missions. Other OSAF sites with predominantly administrative missions are Fort Meade (Low) and Fort McPherson (Moderate).

E.3 Summary

Excellence in one ERCM category does not offset failure in another. One hand does not wash the other; therefore, it is difficult to view the environmental factors in terms of "total score." Each category/subcategory must be evaluated separately. There are numerous considerations including how to weight each of these factors in deciding where to station forces.

	Cultural Resources	Natural Resources	Air Quality	Water Quality	Noise	Contaminated Sites	Public Relations	Land Withdrawal	Population Growth	Overall Risk
APG	X			X	X	XX				XX
Benning		XX			X	XX		X		
Bliss			XX		X		XX	XX		
Bragg	XX	XX		X			X			
Campbell	XX				X		X			
Carson					X		X			XX
Drum	X					XX				
Gordon					X					
Greely	XX						XX	XX		
Hood		XX			XX					
Huachuca	X	XX		X	X					
Jackson										
Knox	X									
Leonard Wood			XX							
Lewis		XX		X		XX	X			
Polk				X				X		
Richardson	XX					XX	XX			
Riley	X				X	XX	X			
Rucker										
Schofield	XX					XX				
Sill					X					
Stewart	X	XX			X		XX			
Wainright	XX						XX	XX		
Yuma	X			X						
	ERCM								CERL	
X~ existing, XX ~ serious/existing, shaded ~ potential										

Figure E-1. Summary ERCM and CERL Environmental Factors Rating

Having placed the meaningfulness of the above environmental factors into context, Figure E-1 summarizes our interpretations of ERCM and CERL evaluations for OSAF problem sites by risk levels: X = "existing", XX = serious existing, and shaded cells = "potential" risks.

E.4 Restoration Costs

We derived Figure E-2 from the Restoration Report to Congress from 1995 to 2000 (draft) (provided by AEC). Costs are derived through the cost to complete process where the installation prepares the estimate for each restoration site. This process is completed during the study process (Site Investigation and Remedial Investigation), when the field determines a most likely estimate.

The Feasibility Study (and beyond) or the Proposed Plan and Record of Decision are used to document the restoration project cost estimates. These estimates are then compiled and published annually in the Restoration Report to Congress. Some observations about this data are:

- Over the life of restoration projects, the cost estimates are less variable from year to year. This could be attributed to cleanup requirement information or process improvements over time. It could also be due to the restoration budget being somewhat stable over the past 6 years.

- Although there are no major fluctuations in the Restoration Cost Requirements/ Budget over this period, there is an unmistakable decline in these funds. The total estimated cost has decreased from 13.6B to 9.6B dollars (-28 percent) over the past 6 years. This is somewhat surprising in light of the growing concern over environmental issues in the Army and elsewhere. A sharp increase or decrease from year to year would naturally drive up the variability of the total estimated cost from year to year.
- Management improvements such as the synchronization of "cost to complete" and "estimated completion date" (around 98/99) may have contributed to the lessening in year-to-year variability over the past 2 years.

MACOM	Installation	1995 Total Estimated Cost	1996 Total Estimated Cost	1996 % Change (-/+)	1997 Total Estimated Cost	1997 % Change (-/+)	1998 Total Estimated Cost	1998 % Change (-/+)	1999 Total Estimated Cost	1999 % Change (-/+)	2000 Total Estimated Cost	2000 % Change (-/+)	Rel. Risk of Remaining Sites: High	Med	Low	Sites with response complete	Estimated Completion FY 20
AMC	Aberdeen Proving Ground	1509002	1468004	-2.7%	1093648	-25.5%	1067226	-2.4%	1036281	-2.9%	749311	-27.7%	121	36	38	53	42
FORSCOM	Fort Campbell	247034	248601	0.6%	116049	-53.3%	93924	-19.1%	62953	-33.0%	41527	-34.0%	7	4	0	49	09
	Fort Hood	17067	19138	12.1%	13549	-29.2%	7211	-46.8%	6829	-5.3%	6829	0.0%					
	Fort Irwin	45061	46166	2.5%	30852	-33.2%	21285	-31.0%	21479	0.9%	20213	-5.9%	0	0	1	38	29
	Fort McPherson	17711	19824	11.9%	13639	-31.2%	7832	-42.6%	7732	-1.3%	7772	0.5%					
	Fort Carson	94506	64060	-32.2%	76959	20.1%	76149	-1.1%	50753	-33.4%	48818	-3.8%	10	14	21	30	17
	Fort Drum	111042	97714	-12.0%	95848	-1.9%	89293	-6.8%	76660	-14.1%	73448	-4.2%	3	1	0	44	24
	Fort Gillem	54332	55365	1.9%	92373	66.8%	63543	-31.2%	19839	-68.8%	19922	0.4%	5	0	0	8	02
	Fort Riley	121872	126616	3.9%	82578	-34.8%	78289	-5.2%	84419	7.8%	83199	-1.4%	5	5	1	59	20
	Fort Stewart	31283	31630	1.1%	25188	-20.4%	26099	3.6%	23249	-10.9%	24043	3.4%	7	1	9	66	07
	Yakima Training Center	10341	10372	0.3%	15202	46.6%	14742	-3.0%	18734	27.1%	2189	-88.3%	1	3	7	39	30
	Fort Lewis	58526	62474	6.7%	74094	18.6%	88238	19.1%	104251	18.1%	79528	-23.7%	7	1	4	36	36
	Fort Bragg	15646	16491	5.4%	26246	59.2%	25312	-3.6%	32997	30.4%	21857	-33.8%	9	0	3	30	07
	Fort Polk	94322	35946	-61.9%	123345	243.1%	87211	-29.3%	33191	-61.9%	30062	-9.4%	4	4	2	12	25
	Fort Hunter Liggett	10516	20460	94.6%	38866	90.0%	38802	-0.2%	32093	-17.3%	29840	-7.0%	5	3	3	23	32
MDW	Fort Myer	7190	7939	10.4%	4555	-42.6%	4548	-0.2%	3985	-12.4%	3588	-10.0%	0	1	0	6	02
	Fort Belvoir	11213	11214	0.0%	2118	-81.1%	2115	-0.1%	2925	38.3%	2854	-2.4%					
	Fort George G. Meade	49366	71729	45.3%	73937	3.1%	67862	-8.2%	69117	1.8%	70169	1.5%	7	1	0	24	04
TRADOC	Fort Sill	104513	96549	-7.6%	46225	-52.1%	46082	-0.3%	44475	-3.5%	32817	-26.2%	2	2	16	48	14
	Fort Bliss	59993	61906	3.2%	43271	-30.1%	40505	-6.4%	31670	-21.8%	23355	-26.3%	8	4	10	55	12
	Fort Eustis	67399	69588	3.2%	51164	-26.5%	48763	-4.7%	48819	0.1%	47219	-3.3%	3	2	3	15	13
	Fort Benning	67103	63829	-4.9%	37747	-40.9%	50078	32.7%	50917	1.7%	48221	-5.3%	16	4	0	23	12
	Fort Story	6947	6954	0.1%	7165	3.0%	7147	-0.3%	7154	0.1%	6280	-12.2%	0	4	0	7	03
	Fort Huachuca	9152	9576	4.6%	9139	-4.6%	8429	-7.8%	8541	1.3%	8485	-0.7%	0	0	3	58	05
	Fort Lee	31133	32975	5.9%	17969	-45.5%	22466	25.0%	22484	0.1%	25200	12.1%	6	4	3	18	15
	Fort Jackson	63445	65876	3.8%	28064	-57.4%	35814	27.6%	37819	5.6%	45098	19.2%	10	8	9	11	25
	Fort Rucker	18019	17884	-0.7%	10923	-38.9%	11227	2.8%	11668	3.9%	15654	34.2%	2	2	3	100	11
	Fort Leavenworth	21434	21890	2.1%	18709	-14.5%	25881	38.3%	25513	-1.4%	20638	-19.1%	11	2	2	52	07
	Fort Knox	24653	25814	4.7%	14581	-43.5%	23487	61.1%	24591	4.7%	21576	-12.3%	14	2	2	30	11
	Fort Leonard Wood	28160	28962	2.8%	10550	-63.6%	16786	59.1%	10071	-40.0%	19006	88.7%	5	2	9	61	08
	Fort Gordon	8680	11473	32.2%	18464	60.9%	22820	23.6%	23829	4.4%	26102	9.5%	19	6	0	12	14
USAR	CE Kelly Support Facility	8995	24170	168.7%	23721	-1.9%	15045	-36.6%	7761	-48.4%	2644	-65.9%	3	2	2	8	16
USARPAC	Fort Richardson	154157	156454	1.5%	89619	-42.7%	84749	-5.4%	88254	4.1%	91014	3.1%	3	1	0	73	20
	Schofield Barracks	70226	68915	-1.9%	62117	-9.9%	61312	-1.3%	60828	-0.8%	58701	-3.5%	1	2	3	118	30
	Fort Wainwright	145146	155715	7.3%	147577	-5.2%	125046	-15.3%	151198	20.9%	161919	7.1%	5	1	2	58	23
	Fort Shafter	10995	11489	4.5%	8380	-27.1%	13862	65.4%	14429	4.1%	16020	11.0%	0	3	6	38	14
	Fort Greely	13036	77790	496.7%	25347	-67.4%	26810	5.8%	23222	-13.4%	23784	2.4%	1	4	10	52	09
USMA	West Point Military Academy	21948	23090	5.2%	17570	-23.9%	17597	0.2%	18398	4.6%	20462	11.2%	10	0	0	18	17

Figure E-2. Historical Cost Estimates and Changes Over 5 Years

Installations develop restoration requirements and send these forward to AEC and HQDA. The Installation Action Plan Workshop and Program Execution Review are some of the mechanisms used to evaluate installation proposals. Once approved, the restoration costs are spread out over "x" number of years based on current Army budget levels and the cost to complete the site restorations at an installation. This is essentially the "synchronization" process mentioned previously. If the budget gets cut in out years or if knowing more about the site suggests it will cost more to restore, the completion date may extend; if the opposite happens, it may retract. The time it takes to finish a site can also extend if monies are pulled from one site and given to a different site (redistribution of funds owing to priorities).

To summarize--Installations develop requirements; budget levels are set; installations program funds and synchronize phase dates. At this point, data is used to set the President's budget. If there are Congressional cuts, adjustments are made at the Army level and installations reprogram accordingly.

E.4.1 MACOM Comments

AMC has a better track record than other MACOMs when it comes to completing the restoration site cleanup process on time and closer to original estimates.

- AMC installations have a rate of just over 2:1 when counting installations where the cost to complete is on the decline.
- TRADOC and FORSCOM, which are predominately OSAF sites, are running at a rate of 1:1.
- For the remaining installations the ratio is approximately 1:1.

Considerable variability exists in cost estimates from year to year. Variability of cost tends to fall within +/- 35 percent of the prior year, which could be used as a simple measure of cost risk when viewing the estimates.

We can explain little of the variability in cost estimates through regression analysis of the cost estimate (dependent variable) and site characteristics, MACOM, year, or combinations thereof (independent variables.

E.4.2 Impact Analysis

The Army has a schedule for remediation operations on its installations. In Figure E-2 we list a number of OSAF installations and the estimated remediation cost as of FY 2000 (Report to Congress).

If an installation is closed before the scheduled time to complete remediation the costs to conduct cleanup could be brought forward to an earlier year. This acceleration of a cost, or paying the bill early, could influence the Army remediation program. By accelerating funding for cleanup at one installation, the Federal Government loses an opportunity to commit these funds to another program (or another installation).

One thing is certain--the FY 2000 estimate for remediation at the above installations will change over time. Of the 195 estimates over the last 5 years for this set of installations, only one did not change between years. All but four estimates change from +/- 95 percent (the other four are +400 percent). If we look at the average change over the period at the installation level, the differences in estimates range from +/- 32 percent. As seen in Figure E-3, there is considerable uncertainty in the eventual cost of remediation, which provides some cost risk with actions that move these costs forward.

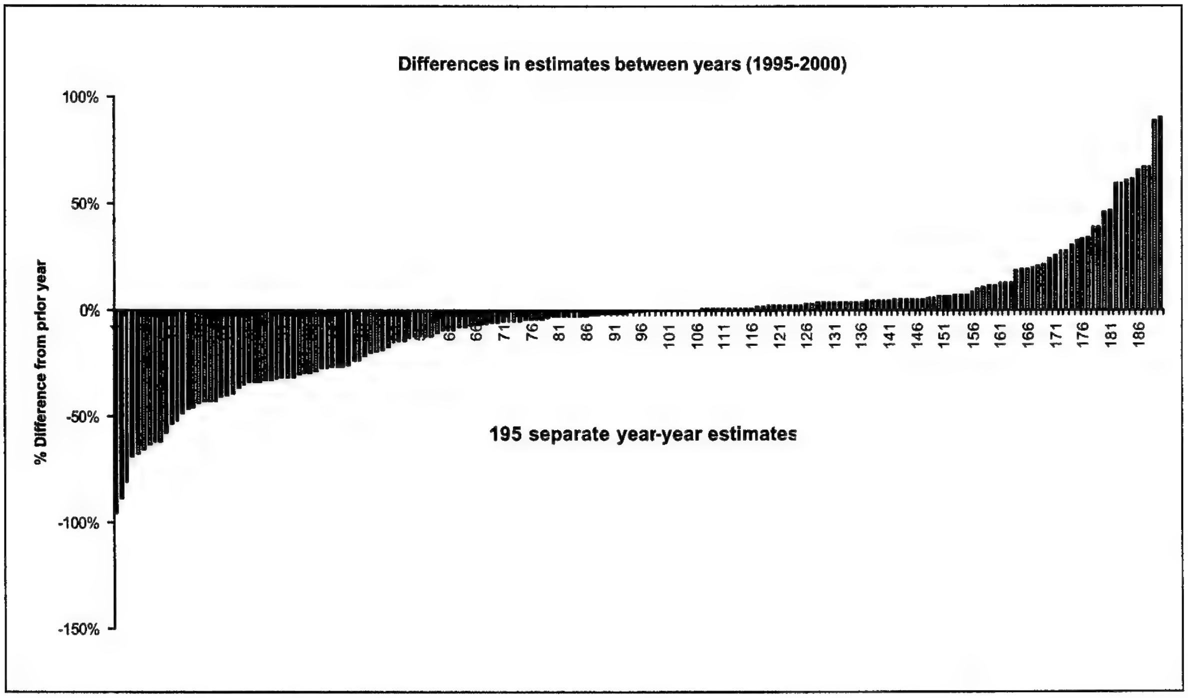


Figure E-3. Differences in Cost Estimates Between Years (less outliers)

APPENDIX F FORMULATION

Indices:

c	facility condition
f	facility category
i	installation
k	maneuver land measured in km^2days
r	range type measured in days
t	installation type
u	unit
y	unit types

Sets:

CA_u	set of installations where unit u can be assigned
IS_i	initial stationing of units at installation i
N	set of ranges r requiring construction to satisfy any shortage
S	set of installations that share training assets
UA_i	set of units that can be assigned to installation i
FIX	set of installations that are "fixed" open
UT_y	set of units of type y

Data: (all \$ are fiscal year 2001 thousands of dollars and all SF are thousands of square feet)

Cost data (units)

$Fcost_i$	fixed cost of keeping installation i open (\$)
$ManCostC_i$	program management cost to close installation i (\$)
$ManCostM_u$	program management cost to move unit u (\$)
$maxMILCON$	maximum one time cost for military construction (\$)
$maxMOVE$	maximum one time cost for transportation costs (\$)
$maxMAN$	maximum management cost (\$)
$maxCOST$	maximum total cost (\$)
$Mcost_{fi}$	military construction (MILCON) cost for facility type f at installation i (\$/SF)
$Rcost_{ir}$	cost for a new range r at installation i (\$/range)
$UPcost_{fi}$	cost to upgrade facilities type f at installation i (\$/SF)
$Vcost_{iu}$	variable cost if unit u is assigned to installation i (\$)
$CostSustain_{fi}$	cost to sustain existing facilities type f at i (\$/SF)
$CostNew_{fi}$	cost to sustain new facilities type f at i (\$/SF)
$TRcost_{iu}$	transportation cost for moving unit u to installation i (\$)

Range data

$RANm_r$	maximum range days on a new range r
$RANkcap_{ik}$	range capacity of type k at installation i (KM^2Day)

$RANkreq_{ku}$	range required of type k for unit u (KM^2Day)
$RANkshort_k$	existing range shortage for range type k (KM^2Day)
$RANrcap_{ir}$	range capacity of type r at installation i (day)
$RANrreq_{ru}$	range required of type r for unit u (day)
$RANrshort_r$	existing range shortage for range type r (day)
$allowRNG_{ir}$	the range shortage allowed for r at installation i (day)
$allowRNG\_S_r$	the starting range r shortage allowed for set S (day)
$allowKM2_{ik}$	the starting KM^2Days overage allowed for maneuver land k at installation i (KM^2Day)
$allowKM2\_S_k$	the starting KM^2Days overage allowed for maneuver land k and set S (KM^2Day)
$moreRNGshort_r$	multiplicative range r shortage for all installations (day/day)
$moreKM2short_k$	multiplicative KM^2Days shortage for all installations (KM^2day/KM^2Day)
$ADDKM2\_S_k$	shortage allowed for maneuver land k and set S (KM^2 Day)
$ADDRNG\_S_r$	shortage allowed for range r and set S (day)
$ADDKM2_{ik}$	shortage allowed for maneuver land k at installation i (KM^2 Day)
$ADDKM2_{ir}$	additive shortage allowed for range r at installation i (day)
$mRNGshort$	the minimum range shortage before a range purchase (days)

Facility data

$FACcap_{cfi}$	facility capacity type f at installation i condition c (SF)
$FACreq_{fu}$	facility required of type f for unit u (SF)
$GREEN_{fi}$	green facility type f at installation i not used by currently stationed units (SF)
$OTHER_{fi}$	other facility type f at installation i not used by currently stationed units (SF)

Adjusted Present Value (APV) factor data

APVBOSss	APV for BOS costs for steady state stationing (years 7-20)
APVBOSsq	APV for BOS costs for status quo stationing (years 1-6)
APVBOS	APV for BOS (years 1-20)
APVMILCON	APV for MILCON (years 1-20)
APVMAINTss	APV for maintenance for steady state stationing (years 7-20)
APVMAINT	APV for maintenance (years 1-20)
APVManage	APV for management (years 1-20)

Penalty data

Penalty	weight of one time costs in objective function

Nonnegative Variables:

$erran_{ir}$	deviation for range type r at installation i (day)
$ekran_{ik}$	deviation for range type k at installation i (KM^2 Days)
$milcon_{fi}$	military construction of facility f at installation i (SF)

$upgrad_{fi}$	conversion of facility f SF in other condition to green condition at installation i (SF)
$range_{ir}$	shortage of range r at installation i
$agreen_{fi}$	green conditioned facilities made available by moves from facility type f at installation I
$usehvy_i$	percent of heavy maneuver land in use on installation i

Binary Variables

$station_{iu}$	1 if unit u is assigned to installation i and 0 otherwise
$close_i$	1 if installation i is closed and 0 if open
$exit_{fi}$	1 when units move from all type f other category facilities at installation i

Objective:

(1) Minimize yearly costs and weighted implementation costs:

$$\begin{aligned}&\sum_{i,u\in UA_i} Vcost_{iu} station_{iu} + \sum_i Fcost_i (1-close_i) + Penalty\Big(\sum_{fi} Mcost_{fi}\, milcon_{fi} \\ &+ \sum_{ir\in N} Rcost_{ir}\, range_{ir} + \sum_{fi} UPcost_{fi}\, upgrad_{fi} + \sum_{i,\,u\in UA_i \text{ and } u\notin IS_i} (TRcost_{iu} + Man\cos tM_u) station_{iu} \\ &+ \sum_i ManCostC_i\, close_i + \sum_{cif} CostSustain_{if}\, FACcap_{cif}\,(1-close_i)\Big)\end{aligned} \tag{0.1}$$

(2) Minimize Net Present Value

$$\begin{aligned}&APVBOSss\left(\sum_{i,u\in UA_i} Vcost_{iu} station_{iu}\right) + APVBOSsq\left(\sum_{i,u\in IS_i} Vcost_{iu} station_{iu} + \sum_i Fcost_i\, close_i\right) \\ &+APVBOS\left(\sum_i Fcost_i\,(1-close_i)\right) \\ &+APVMILCON\left(\sum_{fi} Mcost_{fi}\, milcon_{fi} + \sum_{ir\in N} Rcost_{ir}\, range_{ir} + \sum_{fi} UPcost_{fi}\, upgrad_{fi}\right) \\ &+APVMAINTss\left(\sum_{fi}\Big(CostNew_{fi} milcon_{fi} + \big(CostNew_{fi} - CostSustain_{fi}\big) upgrad_{fi}\Big)\right) \\ &+APVMAINT\sum_{fic} CostSustain_{fi} FACcap_{cfi}(1-close_i) + APVMOVE \sum_{i,\,u\in UA_i \text{ and } u\notin IS_i} TRcost_{iu} station_{iu} \\ &+APVManage\left(\sum_i ManCostC_i\, close_i + \sum_u ManCostM_u station_{iu}\right)\end{aligned} \tag{0.2}$$

Constraint Sets:

$$\sum_{u \in UA_i} FACreq_{fu} station_{iu} \le \sum_c FACcap_{cfi} + milcon_{fi} \quad \forall f,i \tag{2.1}$$

$$\sum_{u \in UA_i \text{ and } u \notin IS_i} FACreq_{fu} station_{iu} \le agreen_{fi} + GREEN_{fi} + milcon_{fi} + upgrad_{fi} \ \forall f,i \tag{2.2}$$

$$agreen_{fi} + upgrad_{fi} \le OTHER_{fi} + \sum_{u \in IS_i} \sum_{i' \ne i \text{ and } i' \in CA_u} FACreq_{uf} station_{i'u} \ \forall f, i \tag{2.3}$$

$$FACcap_{\text{"other"} fi} exit_{fi} \le upgrad_{fi} \ \forall f, i \tag{2.4}$$

$$agreen_{fi} \le FACcap_{\text{"green"} fi} exit_{fi} \ \forall f, i \tag{2.5}$$

$$\sum_{i \in S} \sum_{u \in UA_i} RANrreq_{ru} \, station_{iu} \le \sum_{i \in S} \left(RANrcap_{ir} + erran_{ir} \right) \forall r \tag{2.6}$$

$$\sum_{u \in UA_i} RANrreq_{ru} station_{iu} \le RANrcap_{ir} + erran_{ir} \ \forall i \notin S, r \tag{2.7}$$

$$\sum_i erran_{ir} \le moreRNGshort_r RANrshort_r \quad \forall r \tag{2.8}$$

$$\sum_i ekran_{ik} \le moreKM2short_k RANkshort_k \quad \forall k \tag{2.9}$$

$$erran_{ir} \le rngshort + RANm_r \, range_{ir} \quad \forall \ i \, r \in N \tag{2.10}$$

$$\sum_{i \in S} erran_{ir} \le allowRNG\_S_r + ADDRNG\_S_r \quad \forall r \tag{2.11}$$

$$\sum_{i \in S} eKran_{ik} \le allowKM2\_S_k + ADDKM2\_S_k \quad \forall k \tag{2.12}$$

$$erran_{ir} \le allowRNG_{ir} + ADDRNG_{ir} \quad \forall i \notin S, r \tag{2.13}$$

$$eKran_{ik} \leq allowKM2_{ik} + ADDKM2_{ik} \quad \forall i \notin S, k \tag{2.14}$$

$$\sum_{u \in UA_i} RANkreq_{u\text{"}HV\_MNVR\text{"}} station_{iu} \leq RANkcap_{i,\text{"}HV\_MNVR\text{"}} usehvy_i + ekran_{i\text{"}HV\_MNVR\text{"}} \\ \forall i \notin S, RANkcap_{i\text{"}HV\_MNVR\text{"}} \neq 0 \tag{2.15}$$

$$\sum_{u \in UA_i} RANkreq_{u\text{"}LT\_MNVR\text{"}} station_{iu} \leq RANkcap_{i,\text{"}HV\_MNVR\text{"}} (1 - usehvy_i) \\ + RANkcap_{i,\text{"}LT\_MNVR\text{"}} + ekran_{i\text{"}LT\_MNVR\text{"}} \qquad \forall i \notin S, RANkcap_{i\text{"}LT\_MNVR\text{"}} \neq 0 \tag{2.16}$$

$$\sum_{i \in CA_u} station_{iu} = 1 \quad \forall u \tag{2.17}$$

$$station_{iu} \leq 1 - close_i \quad \forall i \notin FIX, u \in UA_i \tag{2.18}$$

$$\sum_{i' \notin CA_u \text{ and } i' \neq i} station_{iu} \leq close_i \qquad \forall i, u \in UT_{DoD} \text{ and } u \in UA_i \tag{2.19}$$

$$\sum_{fi} Mcost_{fi}\, milcon_{fi} + \sum_{ir \in N} Rcost_{ir}\, range_{ir} + \sum_{fi} UPcost_{fi}\, upgrad_{fi} \leq maxMILCON \tag{2.20}$$

$$\sum_{iu \notin IS_i} TRcosts_{iu} station_{iu} \leq maxMOVE \tag{2.21}$$

$$\sum_{i\,u \notin IS_i} ManCostM_u\, station_{iu} + \sum_i ManCostC_i\, close_i \leq maxMAN \tag{2.22}$$

$$\sum_{fi} Mcost_{fi}\, milcon_{fi} + \sum_{ir \in N} Rcost_{ir}\, range_{ir} + \sum_{fi} UPcost_{fi}\, upgrad_{fi} + \\ \sum_{i\,u \notin IS_i} (TRcosts_{iu} + ManCostM_u)\, station_{iu} + \sum_i ManCostC_i\, close_i \leq maxCOST \tag{2.23}$$

Objective: The objective function (0.1) minimizes variable and fixed cost and a weighted (penalty) contribution for one-time cost. The second possible objective function (0.2) minimizes the net present value for all fixed and recurring costs over a given time period.

Constraint Discussion:

Facilities: The first five equations ensure adequate facilities for units; existing units use "Green" then "Other" facilities, and newly assigned units use available Green, Other upgraded to green condition, and new MILCON.

(2.1) Ensure sufficient existing facility square feet at each installation or satisfy the shortage with MILCON.

(2.2) Ensure sufficient green category facility square feet at each installation for units moved to the installation or satisfy the shortage by upgrading or MILCON.

(2.3)-(2.5) Can only upgrade unused other category facility square feet at each installation or the other/green facilities vacated by a unit stationed at a different installation.

Training: These equations constrain the stationing alternative's shortage of training lands and ranges.

(2.6) to (2.7) Limit realignment so it does not produce any additional training requirement shortfall outside of allowable limits.

(2.8) to (2.9) The allowable shortfall Army wide has to be less than the range shortfall prior to any realignment plus a possible percentage over the original shortage.

(2.10) New ranges must be built to satisfy any shortfall for a subset of range types; however, a new range does not have to be built until a minimum shortage is attained.

(2.11) to (2.12) These equations allow an overage for the set S beyond the starting range or KM2day shortfall.

(2.13) to (2.14) The allowable shortfall for an installation has to be less than the range or KM2day shortfall prior to any realignment plus a possible addition over the original shortage.

(2.15) to (2.16) These equations ensure the light maneuver requirement can be met by the heavy maneuver capacity if heavy capacity is available and has not been fully used by heavy requirements.

Stationing Requirements

(2.17) Each unit must be stationed on an installation.

(2.18) Units are not stationed on a closed installation.

(2.19) Units of type "DOD" are moved only after all other units on the installation are moved and the installation is closed.

One-time Costs

(2.20) to (2.23) respectively limit MILCON, movement, management, and total one-time cost.

Indices	**Description**	**Elements**
c	facility condition	green, other
f	facility category	Operations and administrative, aviation maintenance, department of logistics, supply storage, active training space, community facilities, AMMOSTORE, fuel storage, RCTRN, NGTRN, medical centers, family housing, UEPH, UOPH
i	installation	BELVOIR, BUCHANAN, HAMILTON, KELLY_SPT, MCPHERSON, MEADE, MONROE, MYER, SHAFTER, AP_HILL IRWIN, POLK, BRAGG, CAMPBELL , CARSON, DRUM, HOOD, LEWIS, RICHARDSON, RILEY, SCHOFIELD, STEWART, WAINWRIGHT, CARLISLE, LEAVENWORTH, MCNAIR, WEST POINT, ABERDEEN, BENNING, BLISS, EUSTIS_STO, GORDON, HUACHUCA, JACKSON, KNOX, LEE, LEONARD WOOD, RUCKER, SAM HOUSTON, SILL, CAMP PARKS, DEVENS, DIX , HUNTER LIG , MCCOY, BLANDING , CHAFFEE, GRAYLING, ORCHARD, PICKETT, RIPLEY, SHELBY
k	range type measured in km^{2}days	Heavy maneuver lands, light maneuver lands
r	range type measured in days	zero, record fire, pistol, machine gun, aerial gunnery, infantry squad battle course, multipurpose range complex, multipurpose training range, MOUT facilities, Impact Area
t	installation type	Major training areas, training school, maneuver, MTRAINR, MTRAINA, professional school, command and control
y	types of units	school, ARNG, USAR, TDA, DOD, NONDOD, GARRISON, TOE, TDA_TOE, Medical
u	unit	514 units
	Other Sets Used in Data Manipulations	
a	action	close, move
p	installation data	Government civilian, Military, total base operating costs, cost factor, variable operating costs, fixed operating costs, enlisted, nongovernment civilian, officers, students, construction costs, range costs
pt	personnel types	Enlisted and officer, accompanied and unaccompanied
M	major commands	TRADOC, USARPAC, FORSCOM, MDW, USARSO, USARC
m	sections of units that need to move with the unit	military, TDA, civilian, family

Data element	Equation
Transportation costs	$TR\cos t_{iu} = \sum_{umi} Move_{umi} \quad \forall : i, u \in UA_i$
Starting shortages for KM[2]days	$RANkshort_k = \sum_i \max\left\{0, \left(\sum_{u \in IS_i} RANkreq_{ku} - RANkcap_{ik}\right)\right\}$
Starting shortage for ranges	$RANrshort_r = \sum_i \max\left\{0, \left(\sum_{u \in IS_i} RANrreq_{ru} - RANrcap_{ir}\right)\right\}$
The allowed overage in range days is the current overage +minimum allowed	$allowRNG = if\left(\sum_{\upsilon \in I\Sigma_i} RANrreq_{\rho\upsilon} - RANrreq_{\iota\rho}\right) >$ $\text{mRNGshort}, \left(ceil \frac{\left(\sum_{\upsilon \in I\Sigma_i} RANrreq_{\rho\upsilon} - RANrreq_{\iota\rho}\right) - \text{mRNGshort}}{242} \right) * 242 + \text{mRNGshort}$ $allowRNG = if\left(\sum_{\upsilon \in I\Sigma_i} RANrreq_{\rho\upsilon} - RANrreq_{\iota\rho}\right) \leq 0, \sum_{\upsilon \in I\Sigma_i} RANrreq_{\rho\upsilon} - RANrreq_{\iota\rho}$
Determines extra heavy maneuver lands on *i*	$extrahvy_{i,\text{"}HV\_MNVR\text{"}} = \max(0, RANkcap_{i\text{"}HV\_MNVR\text{"}} - \sum_{u \in IS_i} RANkreq_{u\text{"}HV\_MNVR\text{"}})$
Determines Army wide shortage in lands	$RANkshort_{\text{"}LT\_MNVR\text{"}} =$ $\sum_i \max\left(0, \sum_{u \in IS_i} \left(RANkreq_{u\text{"}LT\_MNVR\text{"}} - RANkcap_{i\text{"}LT\_MNVR\text{"}} - extrahvy_{i,\text{"}HV\_MNV}\right.\right.$
Management costs for closure. Additional equations for moves.	$ManC\,os\,tC_i = \left(PGMC\,os\,t + MBC\,os\,t + CTC\,os\,t\right) * INSTchar_{i\text{"}ACF\text{"}}$ $* \left(\sum_{u \in IS_i, tu \in UTU_u, f \notin ea} FACreq_{uf} + \sum_{u \in IS_i, tu \in UTU_u, f \in ea} 333 * FACreq_{uf} / SFscale \right)$
MILCON costs	$Milcon\cos t_{fi} = (1 + site)(1 + design) Instchar_{iACF} FCG\cos t_{fc\cos t}$
Upgrade costs	$UP\cos t_{fi} = (1 + SIOH)(1 + CONTGC)(1 + DESIGN) UP\cos t_{fi}$
Variable Costs	$V\cos t_{iu} = BOS\cos t_{iu} + H\cos t_{iu}$
RPMA Costs	$RPMA_i = \sum_{fc} Costsustain_{fi} FACcap_{cfi}$
Fixed Costs	$F\cos t_i = Instchar_{i,\text{"}BOSfix\text{"}} + COMMFAC * \cos tsustain_{i,\text{"}COMMFAC\text{"}}$ $+ \sum_{u \in IS_i} \left(bos\cos t_{i,\text{"}garrison\text{"}} + h\cos t_{i\text{"}garrison\text{"}}\right)$

APPENDIX G MODEL PARAMETERS

G.1 Example Inputs

Figure G-1 includes example model inputs for installations, units, and costs. The installations, facilities, units, training lands, and ranges are the available resources or "supply" available to meet Army requirements. Units provide the requirements or "demands" that the installations need to satisfy, including training, housing, and facilities. Some demands are based on the unit's population characteristics and others could be geographical or tied to available installations.

- ❑ Installations (Supply)
  - Installations available
  - Units in force structure
  - Facility capacity by category Group and condition
  - Training facilities, ranges, and lands
  - Unique capabilities
- ❑ Units (Demand)
  - Facility requirements
  - Training requirements
    - Land
    - Ranges
  - Housing requirements
  - Required services
- ❑ Costs
  - Fixed
  - Variable
    - Housing
    - Base Operating (BOS)
    - Facilities maintenance (RPM)
  - Implementation
    - Management
    - Transportation
    - Construction
  - Upgrade
  - Area cost factors
  - Construction factors (SIOH, site prep, etc.)

All data are from CEAC, RPLANS, ARRM, URCM, ISR, MTMC, and BRAC 95 results.

Figure G-1. Example Inputs

To operate an installation, the Army pays fixed and variable costs. An open installation incurs a fixed cost; variable costs depend on the installation's population. If we restation a unit, we incur

implementation costs including management, transportation, upgrade construction, and new construction (SIOH~ Supervision Inspection Overhead, site prep, and other costs).

All data are from ACSIM approved sources including the US Army Cost and Economic Analysis Center (CEAC), Real Property Planning and Analysis System (RPLANS), Army Range and Training Capacity Model (ARRM), Unit Relocation Cost Model (URCM), Military Traffic Management Command (MTMC), and derivations from BRAC 95 results. We describe each input in detail in this appendix.

G.2 Example Calculated Factors

Figure G-2 has an example of calculated factors.

- Installations (Supply)
  - Capacity Utilization Factors for infrastructure and training facilities (buildings, ranges, and training lands)
  - Amount of infrastructure needing upgrade to "green" status
  - A comparison between installations for all factors.
- Units (Demands)
  - Installation related requirements for each unit.
- Costs
  - Cost to move a unit to a different installation: transportation, housing, equipment, and costs.
  - Housing cost for the unit.
  - Management cost for moved units or installations.
  - Personnel costs (RIF, retirement,...)
  - Fixed costs (base operating costs and facilities)
  - Variable costs for each person assigned
  - Construction costs per SF for different facility groups and ranges
  - The cost to provide a unit adequate infrastructure and training facilities at an installation (if a shortage exists).

All Cost algorithms are from URCM (updated)

Figure G-2. Calculated Factors

The first choice for all algorithms is URCM unless algorithms were unavailable or modeling considerations demanded otherwise.

G.3 Model Parameters/Sources

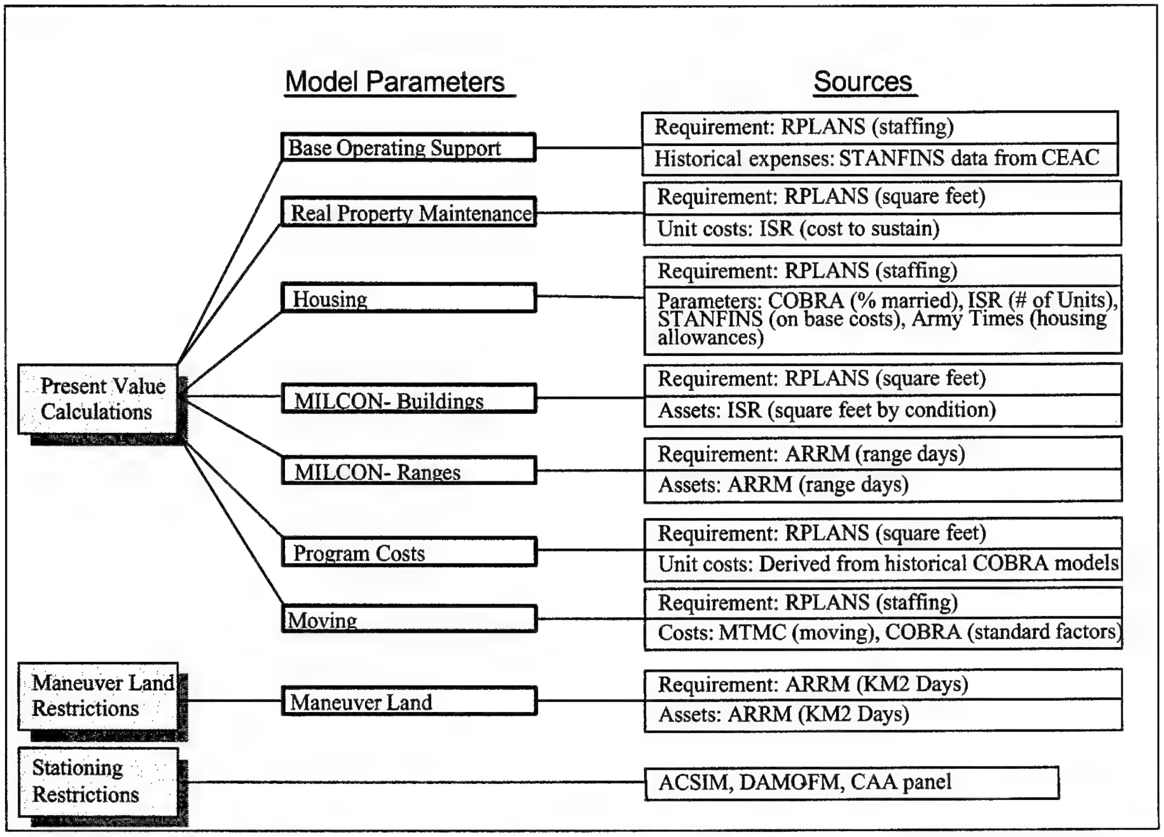


Figure G-3. Model Parameters/Sources

We list the primary parameters in Figure G-3. For each parameter, we provide the name, the source for cost data, and the source for the requirements. The first seven parameters are cost-related and included in all present value calculations. Maneuver lands and stationing restrictions are model parameters that impact cost, but are not direct costs nor included in present value calculations.

G.4 Data Updates

OSAF uses data sources that the Army updates periodically. Table G-1 provides a breakdown of key data elements, provider, source, and the time periods for the current OSAF data.

Table G-1. OSAF Key Data Elements

OSAF Database Requirement	SUB ELEMENT	PROVIDER	SOURCE	UPDATE
Cost Factors	MILCON Unit Costs and Factors URCM Standard Factors	R&K R&K	RPLANS Various Sources	Jan-02 Dec-01
Installation Buildings		VISTA	ISR	Sep-01
Installation Characteristics	Location, population, facility related BOS, HousingAllowances, per diem	R&K R&K	RPLANS DFAS, DTIC	Jan-02 Jan-02
Installation Training Assets		R&K	ARRM	Jan-02
Installation Upgrade Costs		VISTA	ISR	Sep-01
Installation Building Maintenance		VISTA	ISR	Sep-01
Move Civ & Mil	Pack, Store, Line Haul by destination TOE move costs Mileage	MTMC CEAC CAA	Various Sources FORCES JTR	Dec-01 Feb-02 One Time
Unit Requirements	Buildings Training lands & ranges	R&K R&K	RPLANS ARRM	Jan-02 Jan-02

G.5 Base Operating System

Overview

Base Operating Support (BOS) cost has five components:

1. Base Operations (BASOPS),
2. family programs,
3. environment,
4. audio visual, and
5. base communications.

BASOPS is the largest of these five components (82 percent of BOS in FY 99 for the OSAF installations) and covers several installation functions (utilities, municipal services, command element, etc.). Utilities are the largest BASOPS component (20 percent of BASOPS in FY 99 for the OSAF installations).

	Variable
RICHARDSON	Highest
HAMILTON	
BUCHANAN	
WAINWRIGHT	
MONROE	
DRUM	
CARLISLE	
.	
.	
.	
BRAGG	
MEADE	
SILL	
HOOD	
JACKSON	Lowest

(Variable BOS)

- **Major influence on results.**
- **BOS – Base Operations Support:**
  - BASOPS
  - Family Programs
  - Environment (-)
  - Audio Visual (-)
  - Base communications (-)
- **Key assumptions**:
  - Linear estimate is adequate.
- **Observations**:
  - Fixed Costs: OSAF eliminates fixed cost if possible.
  - Variable Costs: Installations with low variable BOS tend to be destinations.
- **Data Source**: STANFINS data from DFAS.

Figure G-4. Base Operating Support (BOS)

OSAF's primary assumption related to BOS is that a linear approximation for an installation's BOS is an adequate representation of true costs (examined in section G.5.1).

Initial analysis shows that, as expected, OSAF prefers to close installations to eliminate fixed BOS charges and favors installations with low variable BOS. Although BOS is one factor of many stationing decisions, results indicate that it is a major influence on OSAF.

The table on the left of Figure G51 illustrates the installations with the highest and lowest variable BOS costs. The BOS data source is the Standard Financial System (STANFINS) from the Defense Finance Accounting System (DFAS).

G.5.1 Base Operating Support (BOS)

OSAF's treatment of BOS is based on COBRA/URCM's approach. COBRA/URCM uses an exponential function to vary BOS cost as the population changes at an installation. The relationship given in "Algorithm Documentation COBRA" is:

$$\text{Re}\,vised\ BOS = Actual\ BOS\left(\frac{\text{Revised Population}}{\text{Actual Population}}\right)^{*BOSIndex} \quad \text{where BOS Index} = 0.56$$

OR

$$\text{Re}\,vised\ BOS = \left(\frac{\text{Actual BOS}}{\text{Actual Population}^{0.56}}\right)*\left(\text{Re}\,vised\ Population\right)^{0.56}$$

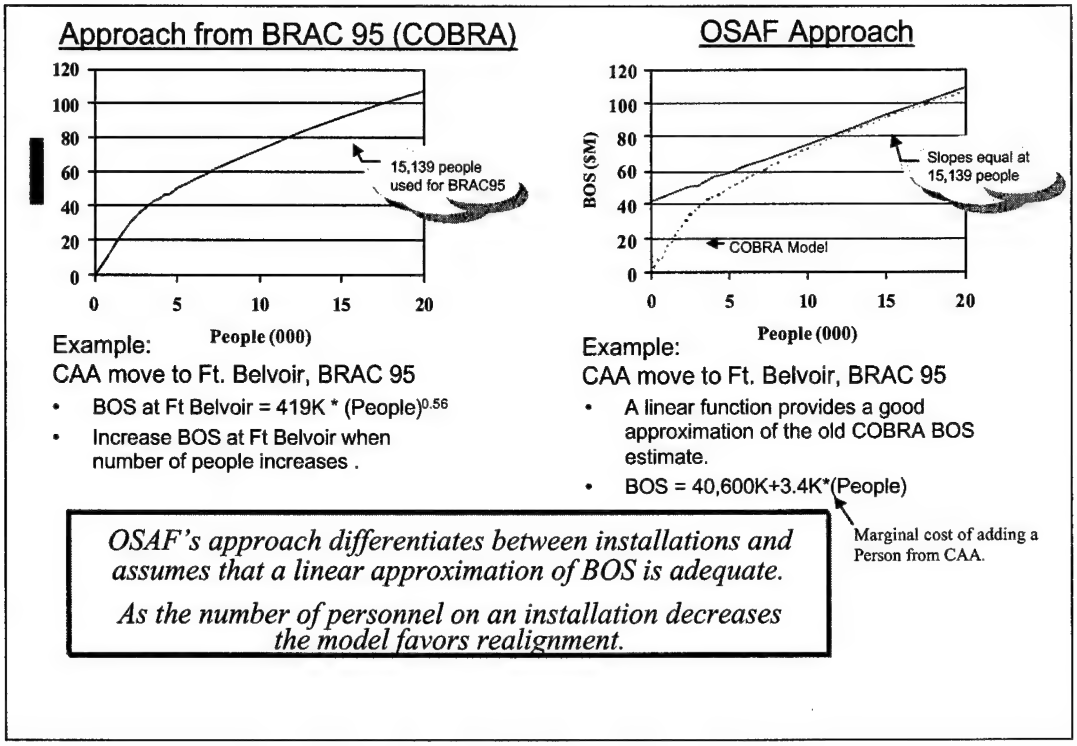


Figure G-5. Base Operating Support (BOS)

The left side of Figure G-5 illustrates this function for Fort Belvoir in the models that COBRA used for BRAC 95. The 419K coefficient represents Fort Belvoir's BOS budget divided by Fort Belvoir's population raised to the 0.56 power. The graph on the left of Figure G-2 shows the appeal of using an exponential function to represent economies of scale of a BOS program.

OSAF is an integer linear program; as such, it cannot use exponential functions; however, we can approximate the exponential function with a piecewise linear function. In our stationing model, we would like the linear model to behave like the exponential model in a neighborhood close to the installation's current population (where most alterations, if any, are likely). If the linear model has the same slope as the exponential model for the current population, then, as an installation's population increases or decreases, the linear model will increase or decrease BOS in a manner similar to the exponential model.

In the Fort Belvoir example, the installation had a starting population of 15,139 people. We can determine the slope of the exponential model by taking its derivative, calculate the slope at 15,139 people, and then replace the exponential function with a line having the same slope. In this case, the slope is \$3.4K/person as shown on the right side of Figure G-5. Notice there are two components to the linear function: a fixed cost which is \$40,600K and a variable cost of \$3.4K/person. We assume that this fixed/variable representation for BOS costs is adequate.

Determining a Linear Model for Each Installation

COBRA calculates a unique exponential model (unique multiplier, exponent is constant at .56) for each installation; therefore we had to determine the form of each of these exponential functions and convert each into a linear form for OSAF. This challenge was complicated by the fact that the derivational basis for the COBRA/URCM exponent of .56 has been lost over time; therefore, we took the following steps to develop appropriate functions:

1. Estimated a new exponent for the exponential function. As with COBRA/URCM, this exponent is used for all installations.

2. Took the derivative of each exponential function and computed the slope of these functions under the installation's starting population.

3. Used the resulting slope as the variable component of the linear function and then computed the fixed component.

Details for these steps are provided in section G.5.2.

G.5.2 Computing Fixed and Variable BOS

Estimate a New Exponent for the Exponential Function

Because the derivation for the 0.56 exponent used in COBRA/URCM was unavailable, the OSAF team used regression techniques to determine an updated exponent that is applicable to OSAF installations using recent cost data.

The regression uses the average BOS cost for FY 98/99 for 37 installations (executed dollars). In some cases, FY 99 costs were used instead of the FY 98/99 average to adjust for accounting anomalies. For example, Fort Hamilton, Fort Myer, Fort McNair, and Fort Buchanan had $0 for FY 98 costs in official databases. The FY 98 BOS cost of $152M at Fort Huachuca was inexplicably high, so the FY 99 cost of $68M was used.

The regression yielded the following equation as the best fit for BOS:

X=Population supported by BOS; W=1 if NY or AK, else 0; Z=1 if maneuver base, else 0.

$$BOS = 402{,}599 * X^{.537} * 1.29^{W} * 1.22^{Z}$$

$R2 = .863$ F= 69.40 Significance Level for F: 100 percent

The model produced acceptable estimates for each installation except for Fort Meade. Fort Meade's FY 98/99 BOS average was much lower than the model estimate. This raised a concern that the accounting records might not provide full visibility of Fort Meade's BOS cost, possibly because Fort Meade is host to the National Security Agency, the largest non-Army tenant among all of the OSAF installations. For this reason, Fort Meade is treated as an outlier. All Fort Meade BOS costs in OSAF come from the equation given above, not the accounting records.

Take the Derivative of the Exponential Function and Determine Slopes

OSAF uses a linear function with a fixed and variable component to estimate BOS. The goal is to have a variable cost component that equals the slope of COBRA/URCM's exponential function for today's cost and population. We accomplish this by taking the derivative of the exponential function and computing the resulting slope. As shown above, the slope is: $B^* (Y'/X')^B * X'^{(B-1)}$ where Y'=Current BOS, X'= Current BOS population, and $B = 0.537$ (the exponent in the exponential function). Figure G-6 shows the slope (i.e., the variable cost component) for each installation for today's cost and population.

Compute the Fixed BOS Component

Fixed BOS = Total BOS – (Variable BOS*Population)

We summarize these steps in Figure G-6.

1. Update COBRA's BOS exponent with regression analysis.

Best fit: $Y = 402{,}599 * (X)^{.537} * (1.29^{W}) * (1.22^{Z})$

Y = BOS; X=Population supported by BOS; W=1 if NY or AK, else 0; Z=1 if maneuver base, else 0.

Based on FY 98/99 average BOS; adjust for accounting anomalies.

Used FY 99 only:Forts Hamilton, Myer, McNair, Buchanan, Huachuca

2. Treat Meade as an outlier; use regression estimate instead of accounting data.
3. Convert exponential function in COBRA into a linear form.

$Y = K_i * (X)^B$

Y=BOS; X=Population supported by BOS

K_i= Coefficient for installation i based on current cost and population

B = BOS exponent used for all installations

Slope = $dy/dx = B^* K_i * X^{(B-1)} = B^*(Y/ X^B) * X^{(B-1)}$

Goal: OSAF's variable cost equals the slope of COBRA's exponential function for today's cost and population.

4. Compute fixed and variable cost for OSAF.

OSAF's variable cost = $B * (Y'/ X'^{B}) * (X')^{(B-1)}$

where Y'=Current BOS; X'= Current BOS population

OSAF's fixed cost = Y' - *(OSAF's variable cost* * X'*)*

Figure G-6. Computing Fixed and Variable BOS

G.5.3 BOS Parameters

Figure G-7 lists the population (actual), total BOS (actual), variable BOS (calculated), and fixed BOS (calculated) for OSAF installations, sorted by population.

Installation	Population	Total BOS	Variable BOS	Fixed BOS
HOOD	49,933	135,157,213	1453	66,325,697
BRAGG	46,326	144,876,699	1679	72,479,898
MEADE	36,840	112,536,677	1640	53,954,237
BENNING	31,993	122,858,156	2062	62,406,502
CAMPBELL	26,437	95,980,443	1949	49,738,469
JACKSON	24,131	62,795,967	1397	31,999,102
SILL	23,954	70,375,422	1577	38,026,421
STEWART-HUNTER AAF	23,636	90,540,222	2057	46,703,495
LEONARD WOOD	23,246	74,524,452	1721	36,628,032
LEWIS	20,164	109,708,973	2921	56,447,459
KNOX	18,736	88,572,695	2538	46,660,163
POLK	18,664	73,209,592	2106	38,412,154
CARSON	17,832	89,389,438	2691	45,746,800
BLISS	16,205	84,937,997	2814	45,862,793
SAM HOUSTON	15,115	93,910,668	3336	50,159,028
GORDON	14,774	61,813,834	2246	33,693,914
BELVOIR	14,491	75,444,085	2795	40,215,905
RILEY	13,757	74,018,333	2889	40,370,150

Installation	Population	Total BOS	Variable BOS	Fixed BOS
EUSTIS-STORY	13,642	64,137,308	2524	33,624,672
SCHOFIELD	13,013	98,162,021	4050	52,506,371
IRWIN	12,560	66,236,443	2831	37,433,849
LEE	11,883	57,033,896	2577	29,447,111
RUCKER	11,360	66,126,965	3125	43,695,715
DRUM	11,269	92,143,477	4390	47,655,217
HUACHUCA	10,934	70,594,505	3467	40,806,041
WEST POINT	10,921	77,522,392	3811	42,525,979
LEAVENWORTH	7,564	35,973,540	2553	19,956,018
SHAFTER	7,106	46,844,500	3540	28,645,360
WAINWRIGHT-GREELY	6,560	72,739,184	5954	37,175,942
MCPHERSON-GILLEM	5,801	35,406,016	3277	18,503,250
MYER	4,106	31,333,417	4097	17,063,566
RICHARDSON	3,165	45,385,559	7700	24,264,459
MONROE	2,970	32,688,659	5910	18,605,129
BUCHANAN	2,692	30,704,266	6124	18,872,698
MCNAIR	1,874	15,096,572	4325	7,480,247
CARLISLE	1,668	13,617,946	4384	7,418,970
HAMILTON	1,082	13,565,512	6732	9,149,320

Figure G-7. BOS Parameters

G.6 Real Property Maintenance (RPM)

Overview

In general, OSAF employs methods similar to those COBRA used during BRAC 95 to calculate stationing cash flows. However, Real Property Maintenance (RPM) is an area where the OSAF approach differs significantly from COBRA.

- ❑ <u>Minor</u> influence on results.
- ❑ Two possible approaches to model Real Property Maintenance:
  - BRAC 95 approach (COBRA)
    - Pro: Economies of scale similar to BOS model.
    - Con: Based on historical costs. Can favor under-budgeted installations.
  - <u>ISR approach</u>
    - Pro: Based on requirement to maintain facility conditions per SF.
    - Con: Unit cost approach does not reflect economies of scale.
- ❑ **Key assumptions:**
  - Model uses ISR approach.
  - Cost calculated for eight groups of facilities.
  - Use sustainment cost for existing facilities.
  - Use new facility cost for upgraded and new facilities.
- ❑ **Observations**: Differences between installations exist; however, they are not as large as other costs and therefore not as influential.
- ❑ **Data Source**: ISR

Figure G-8. Real Property Maintenance (RPM)

The BRAC 95 Approach (COBRA)

COBRA uses an exponential model for RPM similar to their BOS model. This approach illustrates the economies of scale advantages that a large installation has over a small installation, but it has an important weakness. Some of the parameters in the model are based on historical costs, so an installation that chronically underbudgets RPM will be an attractive stationing candidate because it will have artificially low RPM cost.

The Installation Status Report (ISR) Approach

The ISR has two types of cost estimates to maintain facilities. One estimate provides the funding required to maintain facilities in their current condition. The second estimate provides the funding requirement for a new facility. Both of these estimates avoid the problem with the COBRA approach because they are based on a funding requirement rather than historical funding. This means an installation that under-budgets RPM will not have a competitive advantage over other installations because this approach considers a funding requirement, not historical expense. The ISR does not reflect economies of scale like the COBRA approach, but this is a minor flaw compared to the other problems with the COBRA approach.

The OSAF Approach

OSAF uses the ISR estimates for funding requirements and applies them to the same facility groups used for MILCON cost estimates (Admin/Ops, Aviation Maintenance, Vehicle

Maintenance, Supply/Storage, Training/instructional, Community, UEPH, and Ammunition Storage). A special ISR extract provides funding requirements data for each of the OSAF facility groups at each of the OSAF installations.

-- For existing facilities without upgrade: OSAF computes the cost per square foot to maintain facilities in their current condition (based on ISR data) and multiplies by the occupied square feet.

-- For new facilities: OSAF uses the ISR-provided cost per square foot estimate for new facilities and multiplies by the square feet constructed.

-- For upgrade facilities: OSAF uses the ISR-provided cost per square foot estimate for new facilities and multiplies by the square feet upgraded.

Observations

Compared to other cost factors, RPM has a minor effect on OSAF results. Units require the same amount of square footage regardless of location; therefore, Army wide RPM requirements change little between initial stationing and OSAF optimal stationing.

By employing area cost factors (ACFs), the ISR data reflects regional differences in costs. So clearly there is some impact; however, the impact is not large enough to generate significant changes in Army-wide RPM requirements.

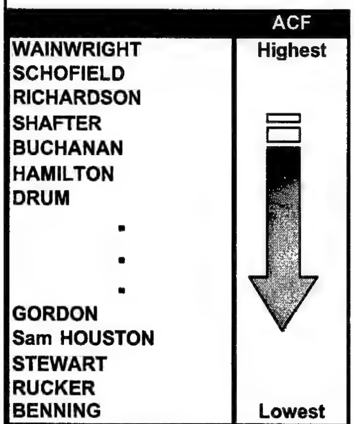
G.7 Construction – Buildings

Overview

OSAF adopts the following business rule to determine the MILCON component of the implementation costs: if a unit moves, the gaining installation will satisfy the unit's facility requirement with buildings that are in "green" condition at the gaining base.

One way to meet this condition is to use surplus assets at the installation, upgrading to "green" condition if necessary. When checking for surplus assets, the model assumes the unused space can be 100 percent utilized. The second means to meet the green requirement is to build new construction.

The model applies this approach to 8 groups of facilities covering 30 Facility Category Codes (FCGs). More details on the methodology are provided on Figure G-9.



(ACF—Area Cost Factor)

- **Major influence on results.**
- **Key assumptions:**
  - Relocated units must move into green condition facilities.
  - Unused space can be 100% utilized
  - Facility Category Groups (FCGs, e.g. administrative facilities) can be aggregated.
- **Observations:**
  - Largest implementation cost.
  - To avoid construction, OSAF may move a smaller unit to a location with higher costs to make a surplus larger and then move in a larger unit.
- **Data Source: RPLANS** for facilities requirements, unit construction costs, and area cost factors. **ISR** for facility assets by condition.

Figure G-9. Construction - Buildings

Observations

Military construction has a major influence on model results. It accounts for 55 to 75 percent-of all implementation costs. OSAF alternatives consistently include stationing that implicitly controls construction cost. For example, installations with low ACFs for construction can be favored as gaining installations.

Often an OSAF solution will include a result where two moves have a lower construction cost than each move if viewed separately. For example, solutions will often include a combination of moves where a small unit moves from an installation that gains a large unit. Moving the smaller unit enlarges the existing surplus or makes MILCON more attractive at the gaining installation. The small unit will move to an installation, which has a small facility surplus. Together these two moves, the large unit and the small unit, result in a reduced construction cost.

G.7.1 Facility Requirements

Methodology

As stated earlier, OSAF adopts the following business rule for MILCON: if a unit moves, its facility requirements will be fully satisfied with buildings that are in "green" condition at the gaining base.

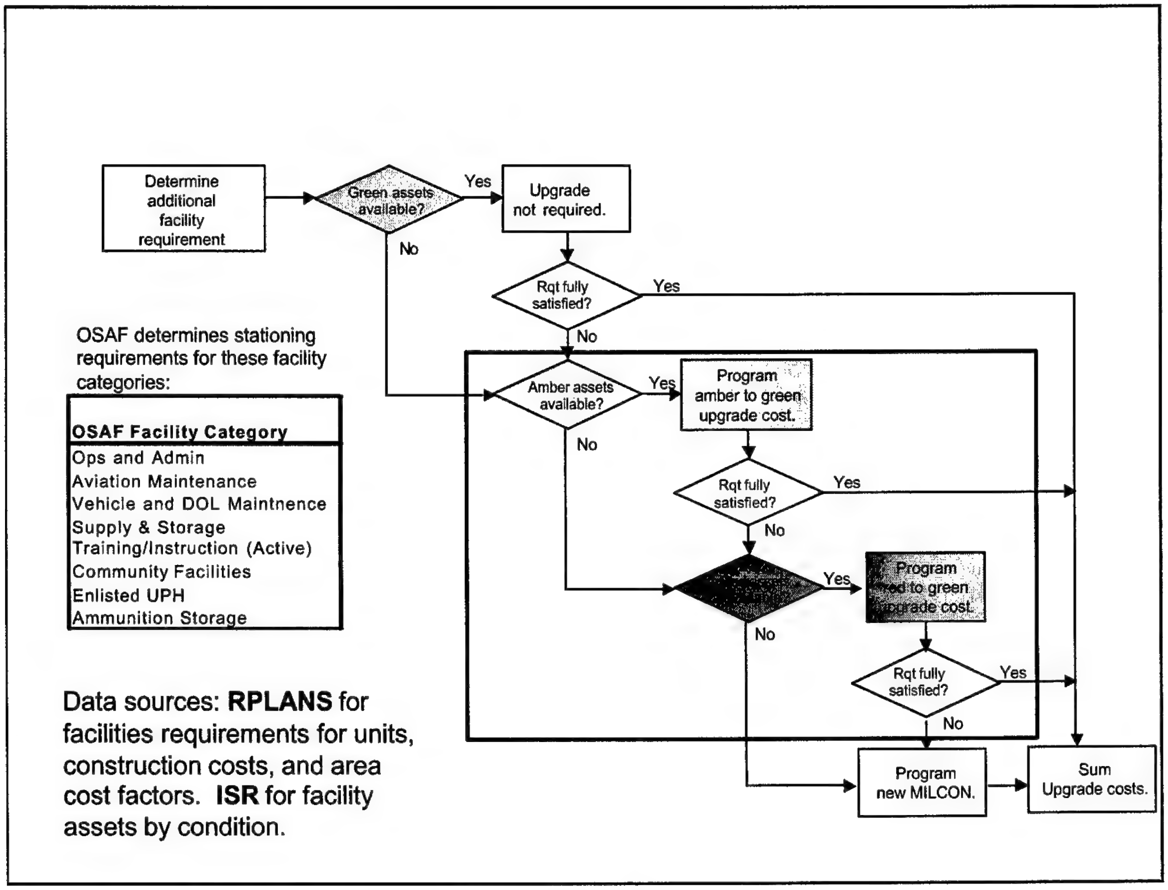


Figure G-10. Facility Requirements

The model accomplishes this by determining the facility requirement for all units. It then determines the installations where surplus assets in "green" condition exist. If excess exists, the assets can be used to fill part or all of a moving unit's requirements. If the unit's requirement is not fully satisfied at this point, the model checks for surplus assets in "other" than green condition (i.e., "other" ~ amber or red condition). If a surplus is available, the model determines a cost to upgrade these assets to green condition. If the requirement is still unsatisfied, OSAF then determines the cost to construct new assets at the gaining base. The total MILCON requirement is the sum of the upgrade and new construction costs. Note the model assumes surplus space can be 100 percent utilized for stationing purposes (a different rate could be used).

OSAF performs this process for each moving unit, for facility category groups, at OSAF installations. OSAF groups facilities into eight categories as shown in Figure G-11.

G.7.2 OSAF Facility Categories

OSAF assumes FCGs can be aggregated without distorting requirements. Figure G-11 depicts the FCGs used in each OSAF facility category. The fact that numerous FCGs are not included in this analysis implies that OSAF's MILCON estimate is a lower bound owing to possible requirements not included in the above FCGs. We could add additional FCGs to OSAF; however, historical analysis has shown that the above groups are the most influential when it comes to stationing.

OSAF Category	FCG Coverage
Operations/Administrative	F14182, F14183, F14185, F60000, F13115
Aviation Maintenance	F21110
Vehicle/DOL Maintenance	F21410, F21885
Supply & Storage	F44210, F44224
Training/Instruction (Active)	F17120, 17131, 17132, 17133, 17134, 17135, 17136, 17137, 17138, F17119
Community Facilities	F74014, F74028, F74053, F72200, F74046,F74021
Enlisted UPH	F7210P, F7213P, F7218P
Ammuntion Storage	F42200

Figure G-11. OSAF Facility Categories

G.8 Construction – Ranges

Overview

OSAF uses the following two key concepts developed in the Army Range and Training Land Program Requirements Model (ARRM) and the Installation Training Capacity (ITC) model.

1. The metric for requirements and range capacity is range-days, which is superior to the number of available ranges. As with ARRM and ITC, the model assumes one range provides 242 range-days of throughput.

2. OSAF works with eight ranges that correspond to those with the highest weights in the ITC model.

a. Zero

b. Record Fire

c. Pistol

d. Machinegun

e. Aerial Gunnery

f. Infantry Squad Battle Course (ISBC)

g. Multipurpose Range Complex (MPRC)

h. Multipurpose Training Range (MPTR)

- **Minor/Moderate influence on results.**
- **Key assumptions:**
  - Use range-days as requirements metric.
  - One range provides 242 range days of throughput.
  - Cost computed for eight types of ranges.
  - If restationing causes the current range-day shortage at an installation to increase by more than 121 range days (1/2 range capacity), then build.
  - Unused capacity can be 100% utilized to fill another requirement
  - MDW treated as one range and one range requirement.
- **Observations:**
  - Not as influential as other costs and maneuver land.
  - Range cost is small compared to other implementation costs.
- **Data Source:** ARRM

Figure G-12. Construction - Ranges

Under today's stationing, there is a shortfall in meeting Army range requirements. To avoid an increase in this shortfall, OSAF builds more ranges if restationing causes the range-day shortage at an installation to increase by more than 121 range-days (1/2 of a range's capacity).

OSAF assumes that any unused capacity can be 100 percent utilized to meet another requirement without regard to scheduling issues involved with coordinating actions on multiple ranges of the same type. For example, an installation with two zero ranges has 484 (2 x 242) zero range-days available.

A special constraint is needed for units in the Military District Washington (MDW). Units at Fort Meade, Fort McNair, Fort Myer, and Fort Belvoir train at Fort A.P. Hill. The model recognizes A.P. Hill as a training node for these installations.

ARRM provided the data for each unit's requirement along with the installation capacities.

Observations

Ranges have a minor impact on model results because the construction cost is small ($1M to $4M) compared to other costs in the model and limited new requirements.

G.9 Maneuver Land

Overview

The availability of maneuver land is an influential constraint in OSAF. OSAF uses the following key concepts developed in ARRM and the ITC model.

1. The metric for requirements and land capacity is KM^2Days (captures the throughput of a training area).

2. There are two types of maneuver land: "heavy" for mounted training involving armor and "light" for all other training (see Appendix K).

3. Units with a heavy training requirement can only use land classified as heavy.

4. Units with a light training requirement can use heavy or light land. Heavy land is only available to light units after all heavy requirements at an installation are met.

- ❑ **Major influence on results.**
- ❑ **Key assumptions:**
  - Use KM^2Days (vs. acres) as requirements metric.
  - Two types of maneuver space: Light and Heavy. Units with light maneuver requirements can use heavy land, if available.
  - Overall Army maneuver land shortfall will not increase.
  - Unused capacity can be 100% utilized to fill another requirement.
- ❑ **Observations:**
  - OSAF avoids deactivating installations with land because stationing options for units with large requirements are very limited.
  - A cost saving move that increases maneuver land shortfall at one installation can trigger a complex series of moves to offset the shortfall.
  - Sensitivity analysis can examine the impact of changing maneuver land restrictions.
- ❑ Data Source: ARRM

Figure G-13. Maneuver Land

Under today's stationing, there is a shortfall in meeting Army maneuver land requirements. OSAF stations units so that the resulting shortfall is no worse than the one the Army accepts today. In doing this, OSAF assumes that any unused capacity can be 100 percent utilized (similar to range assumption). The model can be configured to allow a greater shortfall (lower cost) or force a lower shortfall (increased cost).

ARRM provided the data for each unit's requirement along with each installation's capacity.

Observations

Maneuver land constraints have a major influence on results. They limit the number of installations that can be closed and can also trigger a complex series of moves.

OSAF avoids deactivating installations with maneuver land because stationing options for units with large requirements are very limited. Although some installations have surplus maneuver land, it is hard to exploit these surpluses because most are relatively small. In cases where the surplus is significant, the stationing costs are relatively high.

G.10 Program Costs

Overview

There are three components to program costs: Program management (occurs for years 1-5), Mothball (occurs for years 1-5), and Caretaker (occurs years 3-20 with steady state starting in year 6).

The OSAF team used linear regression to develop cost estimating relationships (CERs) for program management and mothball costs. COBRA scenarios from BRAC 95 provided the data for these regressions. More information on these CERs is provided in Figure G-14.

Very little data exists for caretaker costs. Our estimate is based on an average of budget data for three installations: Fort McClellan, Fort Ord, and Fort Ben Harrison.

- ❑ Minor **influence on results.**
- ❑ **Three components**
  - Program management and Mothball (move or close)
  - Caretaker (close)
- ❑ **Key assumptions:**
  - Program management: $2.56 per square foot requirement of the unit moved (based on regression analysis of past COBRA data).
  - Mothball: $2.51 per square foot transitioning to unoccupied (based on regression of past COBRA data).
  - Caretaker cost: recurring cost ($0.36 per SF, based on average of budget data).
- ❑ **Observations:** Very minor cost; does not influence decisions.
- ❑ **Data Source:** Past COBRA models and base closure budgets from ACSIM.

Figure G-14. Program Costs

Observations

Typically, program costs are less than 10 percent of implementation costs and only have a minor impact on stationing alternatives.

G.10.1 Program Cost

Figure G-15 provides a summary of the program and mothball cost estimating relationships OSAF uses.

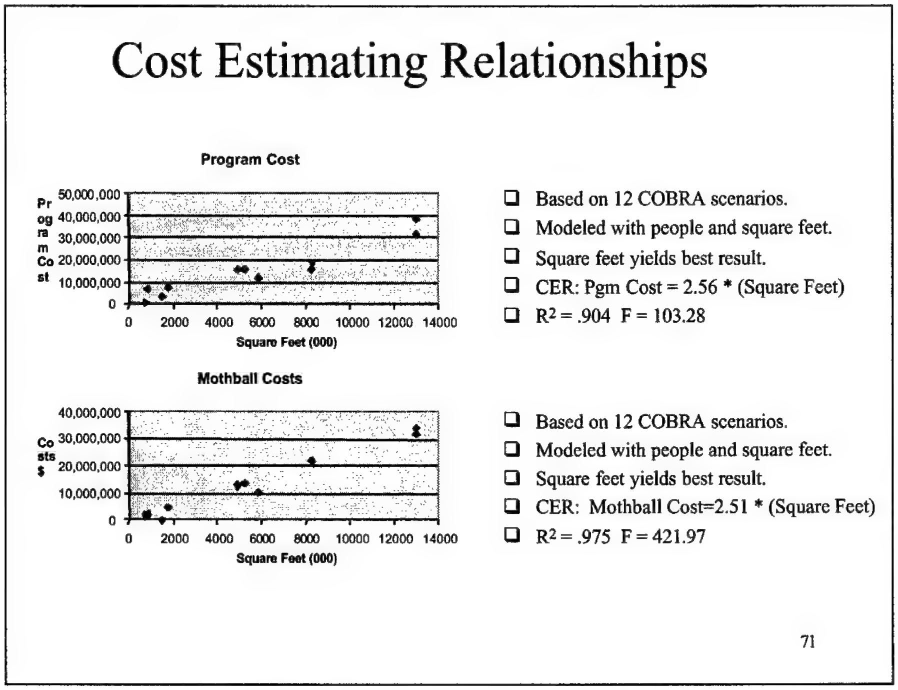


Figure G-15. Cost Estimating Relationships

G.11 Moving Costs

Overview

OSAF covers a large range of moving costs (Figure G-16). In general, moving costs include all mission and support equipment, packing, storage, and line haul costs for mission/support equipment and household goods, real estate transaction costs, and civilian separation costs.

OSAF assumes no costs for loss of experience and new recruitment. A cost could be applied if necessary.

During any year, a number of military personnel have a normal permanent change of station (PCS) rotation. Because the majority of closures or moves take several years to complete we assume that some military (about half) reach the gaining station through PCS.

An official data source is not available to estimate the impact of distance on civilian decisions to quit, retire, or move; therefore, we do not include a penalty for such actions and civilian moves are based on quit rates, retirement rates, and home ownership rates.

Moving costs are discussed in detail in the next sections.

- ❑ Minor influence on results.
- ❑ **Key assumptions:**
  - includes all mission and support equipment, packing, storage, and line haul costs for mission/support equipment and household goods, real estate transaction costs, and civilian separation costs.
  - No penalties for loss of experience and new recruitment.
  - if a unit moves, some military (about half) reach the gaining station through normal Permanent Change of Station (PCS) rotation.
  - Distance of move does not affect civilian decisions to quit, retire, or move.
  - Civilian moves based on quit rates, retirement rates, and home ownership rates.
- ❑ **Observations**: OSAF moves units extra distances to low cost BOS installations.
- ❑ **Data Source**: MTMC for packing storage and line haul cost. FORCES model for equipment movement costs.

Figure G-16. Moving Costs

G.11.1 Cost Components for Moving

Observations

Typically, moving costs are less than 20 percent of implementation costs and only have a minor impact on alternatives.

- ❑ Cost to move TOE equipment (military)
- ❑ Cost to move TDA equipment (civilian and military)
- ❑ Cost to move personnel and families (civilian and military)
- ❑ Cost to move privately owned vehicles (civilian and military)
- ❑ House hunting costs (civilian)
- ❑ Home purchasing cost (civilian)
- ❑ Per diem cost (civilian)
- ❑ Priority Placement Service (PPS) cost (civilian)
- ❑ Real Estate Investment Tax Adjustment (RITA) cost (civilian)
- ❑ Civilian separation costs

Figure G-17. Cost Components for Moving

Components in OSAF moving costs are in Figure G-17.

An OSAF solution will often feature units that incur extra moving costs by moving to a distant installation rather than a closer one because the distant installation has cost advantages in terms of MILCON, BOS, or housing. Under the MILCON discussion, it was noted that the model often prefers moving two units instead of one when the move reduces MILCON, the largest implementation cost.

For the remainder of the transportation cost discussion, we use the sets, parameters, and variables defined below.

sets

d	military status (both married and unaccompanied)
e	movement of equipment types and other requirements (TDA, civilian household goods (CHHG), military household goods (MHHG), house hunting (HH), civilian POV (CPOV), military POV (MPOV), per diem (PD), priority placement service (PPS), PCS, real estate investment tax adjustment (RITA), house purchase (HPUR), separation costs (SEP), retirement costs (RET), early retirement (ERET), reduction in force (RIF), unemployment costs (UNEMP), housing cost on base and leased (HUAC)
i	installation
m	military types (enlisted and officer)
p	personnel types (civilian, military, students)
u	unit

scalars

%Eret	URCM standard factor for civilian early retirement (percent)
%Nomove	URCM standard factor for civilians that do not move (percent)
Air	URCM standard factor for air cost per mile (#/mile)
Atour	average tour length for military (months)
Civret	URCM standard factor for civilian retirement pay factor (percent)
Civrif	URCM standard factor for civilian RIF (percent)
Civsal	URCM standard factor for civilian salary ($)
Cpcs	URCM standard factor for civilian PCS (percent)
Cunemp	URCM standard factor for civilian weekly unemployment compensation ($)
Hap	URCM standard factor for homeowner assistance program ($)
HO	URCM standard factor for home ownership (percent)
Hssr	URCM standard factor for home sales rate reimbursement (percent)
Lostciv	% civilian turnover (15%) + % early retire (10%) + % regular retire (3%) + % that do not move + % unwilling to move (6%)
Mhsr	URCM standard factor for max home sale reimbursement (percent)
Nmhp	URCM standard factor for national medium home price ($)
Pov	URCM standard factor for POV reimbursement ($)
Ppr	URCM standard factor for priority placement rate (percent)
Pps	Priority placement service (percent)
Ppspcs	URCM standard factor for PPS that includes PCS (percent)
Wunemp	URCM standard factor for the number of weeks civilians get weekly unemployment compensation (weeks)

Parameters

$\%M_{md}$	Percent military type *m* of status *d*(percent)
Acf_i	Area cost factor for installation *i*(percent)
$AHsg_{imd}$	Housing units available for type *m* at installation *i* (government owned and leased) status *d* (#)
$Allow_{md}$	URCM standard factors for housing allowance, enlisted ~ E5, officers ~03 ($)
Alw_{im}	the number of military type *m* at installation *i* that are on housing allowance (percent)
$Cost_{euii`}$	Cost to move type e of unit u from *i* to *i`*($ per 100 ton miles)
$EMove_{ueii`}$	Equipment movement requirement of type *e* in unit *u* (tons)
Hc_i	Housing cost at installation *i* for FY 98/99 ($)
$HCost_{mudi}$	Cost to house military of type *m* status *d* in unit *u* to installation *i* ($)
Hsg_{im}	Housing units available for type *m* at installation *i* (government owned and leased) (#)
$HUCost_i$	Housing unit cost at installation *i* ($)
IS_i	Units initially stationed at installation *I* (unit move)
Isr_{im}	ISR maintenance cost to sustain conditions an installation *i* type *m* ($)
$M_{ii`}$	Mileage from i to i` (miles)
$MCost_{mudii`}$	Cost to move military of type *m* status *d* in unit *u* ($ per 100 ton miles)
$MUnit_{um}$	Military in unit *u* type *m* (#)
Mwt_{md}	Standard weight for military m of status *d* (tons)
$NMil_{mud}$	Number of military moved of type m for unit u status *d* (#)
Pd_i	Per diem cost for installation *i*($)
$PMove_{upii`}$	Personnel moved of type *p* in unit *u* (#)
$PUnit_{up}$	Personnel in unit *u* type *p*
$S_{ii`}$	Cost per hundred pounds to pack, store, and line haul from starting installation *i* to *i`* as provided by MTMC ($ per 100 lbs)
WT_e	Allowed weight for equipment per person type *e* (lbs/100)

G.11.2 Moving Equipment

Cost to Move TOE Equipment (military)

The Force and Organization Cost Estimating System (FORCES) is the source for moving cost estimates. The Army Cost and Economic Analysis Center (CEAC) manages FORCES and provided us a data extract for OSAF. This extract includes the cost to move TOE equipment for each RPLANS major unit from its current location to every possible OSAF destination.

- ❑ Demand: RPLANS (unit structure and size)
- ❑ Supply: Maximum moving cost allowed in model
- ❑ Cost for TOE: FORCES
- ❑ Cost for TDA: COBRA/URCM Standard Factor (710 lbs/person); MTMC provided packing, storage, and line haul costs per 100 lbs for each destination.

Figure G-18. Moving Equipment

Cost to Move TDA Equipment (civilian and military)

This cost includes the packing, storage, and line haul costs to ship mission and support equipment for TDA units. It covers items like office equipment, files, personnel computers, etc. OSAF uses the same standard factor for the weight of this equipment (W_{TDA} = 710 pounds/person) as used in the BRAC 95 COBRA models.

The Military Traffic Management Command (MTMC) prepared a data extract that provides packing, storage, and line haul costs for 100 pounds of household goods from any OSAF installation to all other OSAF installations. We assume that the costs for shipping household goods are applicable for shipping the type of TDA equipment described above.

Given the assumptions described above, the formula for calculating the TDA moving costs for unit u from installation i to i' is:

$$EMove_{ueii'} = WT_e * \sum_{p} PUnit_{up} * S_{ii'}$$

$$\forall u,\ e = \text{TDA},\ p = \text{military,civilian}$$

Note: There are some RPLANS major units that have a mix of TOE and TDA military personnel. In these cases, TOE military is subtracted from total military to yield TDA military.

G.11.3 Moving Personnel and Families

Cost to Move Personnel and Families (civilian)

This cost includes the packing, storage, and line haul cost of household goods for civilian personnel and their families. It is based on the number of civilians who will move and does not include civilians who leave or retire before the move takes place or are otherwise unwilling to move.

- Civilian
  - Demand: RPLANS (unit structure and size) with adjustments for separations.
  - Supply: Maximum moving cost allowed in model.
  - Cost: MTMC provided packing, storage, and line haul costs per 100 lbs for each destination along with average weight per move per civilian.
- Military (Three parts: married officer, married enlisted, and unaccompanied military)
  - Demand: RPLANS (unit structure and size) with adjustments for PCS.
  - Supply: Maximum moving cost allowed in model.
  - Cost: MTMC provided packing, storage, and line haul costs per 100 lbs for each destination along with average weight per move per military.

Figure 19. Moving Personnel and Families

The formula for number of civilians moved is:

$$Cost_e = 0 \text{ for moves under 50 miles, otherwise}$$

$$= PUnit_{u\text{"civilian"}} * (1 - LostCIV) * WT_e * S_{ii'}$$

$\forall u, e$=CHHG

Cost to Move Personnel and Families (military)

This cost includes the packing, storage, and line haul cost of household goods for military personnel and their families. The approach is similar to the approach used for civilians with two key differences.

1. The method to determine the **number** of military to move differs from the method for civilians. There are two reasons for this. First military reassigned from one installation to another generally do not have the option to quit, retire, or otherwise refuse the move. Second, a substantial portion of the military (about half) would have received a PCS whether or not particular units have been restationed. In other words, military personnel generate substantial moving costs regardless of restationing actions.

OSAF uses the COBRA/URCM assumption that the proportion of military that would have moved due to normal PCS rotation is 12 divided by the average tour length given in months. For example, if the average tour length is 24 months, then 12/24ths, or half, of the military personnel would have moved regardless of restationing actions.

2. A second difference is that the population is split into three parts: married officers, married enlisted, and unaccompanied military.

It should also be noted that OSAF assumes that the student population does not generate moving costs. If a school is moved, the move will be timed in a fashion to prevent interruption of student instruction. OSAF calculates the proportion of military to move as follows:

$$MCost_{mudii'} = 0 \text{ for moves under 50 miles, otherwise}$$

$$= MUnit_{um} * \frac{\left(\sum_m MUnit_{um} - PUnit_{u\text{"Student"}}\right) * \left(1 - \frac{12}{Atour}\right)}{\sum_{md} MUnit_{um}} * \%M_{md} * MWT_{md} * S_{ii'} \quad \forall umd$$

1. A married officer's move = 6,492 lbs/person; the FY 98/99 average per move as provided by MTMC,

2. Unaccompanied military move = 2,378 lbs/person (CAA estimate), and

3. Married enlisted move = 4,454 lbs/person; the FY 98/99 average per move as provided by MTMC.

G.11.4 Moving Privately Owned Vehicles

Cost to Move Privately Owned Vehicles (civilian)

As with civilian household goods, this cost is based on the number of civilians who will move and does not include civilians who leave or retire before the move takes place or are otherwise unwilling to move. To calculate this cost, OSAF used the URCM standard factors: (1) percent civilian turnover = 15 percent, (2) percent early retire = 10 percent, (3) percent regular retire = 3 percent, and (4) percent unwilling to move =6 percent.

- ❑ Civilian
  - Demand: RPLANS (unit structure and size) with adjustments for separations.
  - Supply: Maximum moving cost allowed in model.
  - Cost: COBRA/URCM standard factor for POV reimbursement; Joint Travel Regulation mileage.
- ❑ Military
  - Demand: RPLANS (unit structure and size) with adjustments for PCS.
  - Supply: Maximum moving cost allowed in model.
  - Cost: COBRA/URCM standard factor for POV reimbursement; JTR mileage.

Figure G-20. Moving Privately Owned Vehicles

The formula for number of civilians moved is:

$$PMove_{u\text{"civilian"}ii'} = PUnit_{u\text{"civilian"}} * (1\text{-LostCIV})$$

$$Cost_{euii'} = 0 \text{ for moves under 50 miles, otherwise}$$

$$= PMove_{u\text{"civilian"}ii'} * M_{ii'} * Pov \quad \forall u,\ e\text{=CPOV}$$

Cost to Move Privately Owned Vehicles (military)

The approach is similar to the civilian POV approach except calculations for number of military required to move are different (see the discussion under military household goods).

$$Cost_{euii'} = 0 \text{ for moves under 50 miles, otherwise}$$

$$= \left(\sum_m MUnit_{um} - PUnit_{u\text{"Student"}}\right) * \left(1 - \frac{12}{Atour}\right) * M_{ii'} * Pov \quad \forall u,\ e\text{=MPOV}$$

G.11.5 Civilian House Hunting

- Demand: RPLANS (unit structure and size) with adjustments for separations.
- Supply: Maximum moving cost allowed in model.
- Cost: COBRA/URCM standard factor for air transport cost/mile; JTR mileage; gainer's per diem.

Figure G-21. Civilian House Hunting

Cost of House Hunting (civilian)

As with civilian household goods, this is based on the number of civilians who will move and does not include civilians who leave or retire before the move takes place or are otherwise unwilling to move. The estimate assumes civilians (two people) make two round trips for house hunting purposes. Like COBRA/URCM, OSAF assumes 17.5 days of per diem.

$$
\begin{aligned}
Cost_{euii'} &= 0 \text{ for moves under 50 miles, otherwise} \\
&= PMove_{u\text{"}civilian\text{"}ii'} * (2[\text{people}] * 4[\text{trip legs}] * M_{ii'} * air + 17.5 * PD_{i'}) \\
&\forall u, e = HH
\end{aligned}
$$

Note: trips are round trip, comments are [ ].

G.11.6 Civilian Home Purchase

Cost of Civilian Home Purchase

We assume that the Government will pay real estate transaction costs (e.g., closing costs) that civilians will incur as a result of realignments. As with civilian household goods we estimate the number of civilians who will move without including civilians who leave or retire before the move takes place or who are otherwise unwilling to move. Unlike civilian household goods, a further adjustment is needed for home ownership. As a result, OSAF uses the standard factor for home ownership rate that was used by COBRA in BRAC 95, 64 percent, along with standard factors for (1) percent civilian turnover (15 percent), (2) percent early retire (10 percent), (3) percent regular retire (3 percent), and (4) percent unwilling to move (6 percent).

- ❑ Demand: RPLANS (unit structure and size) with adjustments for separations and home ownership.
- ❑ Supply: Maximum moving cost allowed in model.
- ❑ Cost: COBRA/URCM standard factors for home ownership rate, national median home price, home sale reimbursement rate, maximum home sale reimbursement, and home owners assistance program receiver rate; JTR mileage; area cost factors

Figure G-22. Civilian Home Purchase

The formula for number of civilians moved is:

$$PMove_{u"civilian"ii'} = PUnit_{u"civilian"} * (1 - LostCIV)$$

$$Cost_{euii'} = 0 \text{ for moves under 50 miles, otherwise}$$

$$HO * PMove_{u"civilian"ii'} * \begin{pmatrix} Min\ (Nmhp * Hsrr * Acf_i, Mhsr) * (1 - Hap) \\ + Min\ (Nmhp * Hsrr * Acf_{i'}, Mhsr) \end{pmatrix}$$

$$\forall u, e = \text{HPUR}$$

G.11.7 Civilian Per Diem

Cost of Travel (civilian)

This is the per diem cost that occurs as civilians move and is different from the per diem paid during house hunting. As with civilian household goods, this is based on the number of civilians who will move. The estimate assumes one day is needed for each 350 miles of travel.

- ❑ Demand: RPLANS (unit structure and size) with adjustments for separations.
- ❑ Supply: Maximum moving cost allowed in model.
- ❑ Cost: JTR mileage; gainer's per diem.

Figure G-23. Civilian Per Diem

$Cost_{euii'} = 0$ for moves under 50 miles, otherwise

$$PMove_{u"civilian"ii'} * \left(\frac{M_{ii'}}{350} * Pd_{i'}\right)$$

$\forall u$, e=per_diem

350 ~ miles traveled per day.

G.11.8 Real Estate Investment Tax Adjustment (RITA)

Real Estate Investment Tax Adjustment (RITA) Cost (civilian)

This cost compensates civilians for the income tax paid for house hunting, house purchase, POV relocation, and per diem reimbursements.

- ❑ Demand: Reimbursement for house hunting, house purchase, POV relocation, and per diem costs.
- ❑ Supply: Maximum moving cost allowed in model.
- ❑ Cost: Marginal income tax rate.

Figure G-24. Real Estate Investment Tax Adjustment (RITA)

$$Cost_{"RITA"uii'} = 0.28 * \sum_{e \in HH, HPUR, CPOV, PD} Cost_{euii'} \; \forall u$$

G.11.9 Civilian Separation Costs

Civilian Separation Costs

This covers the cost of early retirements, reduction in force (RIF), and unemployment compensation. It is assumed that these costs are the same for all destinations.

- ❑ Demand: RPLANS (unit structure and size) adjusted for separations.
- ❑ Supply: Maximum moving cost allowed in model.
- ❑ Cost: COBRA/URCM standard factors for average civilian salary, civilian retirement pay factor, civilian RIF pay factor, average weekly unemployment cost, number of weeks eligible for unemployment.

Figure G-25. Civilian Separation Costs

$$Cost_{"SEP"\,uii'} = \sum_{e \in ERET, RIF, UNEMP} Cost_{euii'}, \text{ where}$$

$$Cost_{"ERET"\,uii'} = Punit_{up} * (\%Eret) * Civsal * Civret$$

$$Cost_{"RIF"\,uii'} = Punit_{up} * (\%Nomove) * Civsal * Civrif$$

$$Cost_{"UNEMP"\,uii'} = Punit_{up} * (\%Nomove) * Cunemp * Wunemp$$

$$\forall u$$

G.12 Housing and Quarters

Overview

There are four components to housing and quarters cost:

1. Unit cost for married enlisted personnel.
2. Unit cost for married officers.
3. Unit cost for unaccompanied enlisted personnel.
4. Unit cost for unaccompanied officers.

Details on these components are covered in the next four figures.

	Housing
BUCHANAN	Highest
HAMILTON	
WEST_POINT	
MCPHERSON	
RICHARDSON	
SCHOFIELD	
SHAFTER	
.	
.	
.	
SILL	
LEONARD WOOD	
POLK	
KNOX	
RUCKER	Lowest

(Sorted by enlisted costs)

- **Moderate influence on results**
- **Key Assumptions:**
  - The private market can meet new housing requirements.
  - Average married/unmarried % applies.
  - For units that do not move: Housing and quarters cost based on housing budgets, availability of quarters, and allowances.
  - For relocated units:
    - Officers and married enlisted receive housing allowances.
    - Unmarried enlisted housed in quarters.
- **Observations**: For units with a heavy military population, the model favors installations with low variable housing allowances (VHA).
- **Data Source**: STANFINS cost data from DLA, Army Times for allowances.

Figure G-26. Housing and Quarters

Observations

The effect of housing and quarters cost depends on the composition of a unit's population. For units with a large proportion of civilians in the population, the effect is small (and sometimes

nonexistent). However, for units with a large proportion of military, housing and quarters has a major influence on the results. A typical OSAF solution will usually include units with some military personnel moving to installations with low housing cost.

G.12.1 Housing: Married Enlisted Personnel

Housing for Married Enlisted Personnel

OSAF uses two costs for every RPLANS major unit that has enlisted military personnel: 1) the cost before the unit moves and 2) the cost if the unit moves.

- ❑ Starting location
  - Key assumption: Housing cost is a weighted average of 1) cost of on-post housing and 2) private sector housing (housing allowances).
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill requirement not met by on-post housing.
  - Cost: Housing expenses for on-post housing and housing allowances for private sector housing.
- ❑ Gaining location
  - Key assumption: Private sector can fill 100% of requirement.
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill 100% of the requirement.
  - Cost: Housing allowances

Figure G-27. Housing: Married Enlisted Personnel

The Cost Before Moving (Enlisted)

There are four steps to compute this estimate:

1. Estimate the unit cost of housing for on-base and leased housing.
2. Estimate the number of on-base and leased housing that married enlisted personnel occupy.
3. Estimate the number of married enlisted personnel living on housing allowances.
4. Calculate the unit cost of housing for on-base, leased, and allowances.

1. Estimate the cost of housing per unit for on-installation and leased housing.

$$HUCost_i = \frac{Hc_i}{Hsg_{i,\text{"enlisted"}}}, \quad \forall i$$

2. Estimate the number of on-base and leased housing that enlisted personnel occupy.

$$AHsg_{i,\text{"enlisted","married"}} = Hsg_{i,\text{"enlisted"}} * \frac{\sum_{u} Munit_{u,\text{"enlisted"}} * \%M_{\text{"enlisted","married"}}}{\sum_{m,\, u\in IS_i} Munit_{um} * \%M_{m,\text{"married"}}}, \quad \forall i$$

3. Estimate the number of married enlisted personnel living on housing allowances.

$$Alw_{im} = MAX \sum_{u} \left(Munit_{um} * \%M_{m,\text{"married"}} \right) - AHsg_{im\,\text{"married"}}, 0 \quad \forall im = \text{enlisted}$$

4. Calculate the unit cost of housing for on-base, leased, and allowances.

$$HCost_{mudi} = \frac{HUCost_i * AHsg_{imd} + Allow_{md} * Alw_{im}}{Munit_{um} * \%M_{md}}$$

$$\forall\, u, i, m = enlisted, d = married$$

The Cost if Moved (Married Enlisted)

OSAF assumes that a unit that moves finds 100 percent of its housing in the private market. Hence, its housing requirement is paid for through housing allowances stated above (#4) where i is the gaining installation.

G.12.2 Housing: Married Officers

Housing for Married Officers

The method is very similar to the methodology for married enlisted personnel. Once again, OSAF uses two costs for every RPLANS major unit which has military officers: (1) the cost before the unit moves and (2) the cost if the unit moves.

- Starting location
  - Key assumption: Housing cost is a weighted average of 1) cost of on-post housing and 2) private sector housing (housing allowances).
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill requirement not met by on-post housing.
  - Cost: Housing expenses for on-post housing and housing allowances for private sector housing.
- Gaining location
  - Key assumption: Private sector can fill 100% of requirement.
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill 100% of the requirement.
  - Cost: Housing allowances

Figure G-28. Housing: Married Officers

The Cost Before Moving (Officer)

As with married enlisted, there are four steps to compute this estimate:

1. Estimate the unit cost of housing for on-base and leased housing.
2. Estimate the number of on-base and leased housing that married officers occupy.
3. Estimate the number of married officers living on housing allowances.
4. Calculate the unit cost of housing for on-base, leased, and allowances.

1. Estimate the cost of housing per unit for on-base and leased housing. This is exactly the same computation used in step #1 for enlisted personnel.

2. Estimate the number of on-base and leased housing that officers occupy. This is the same calculation as step #2 for enlisted, but completed for officers.

3. Estimate the number of married officer personnel living on housing allowances. This is the same calculation as step #3 for enlisted, but completed for officers.

4. Calculate the unit cost of housing for on-base, leased, and allowances. This is the same calculation as step #4 for enlisted, but completed for officers.

The Cost if Moved (Officer)

As with enlisted, OSAF assumes that a unit that moves finds 100 percent of its housing in the private market. Hence, its housing requirement is paid for through housing allowances of the gaining installation.

G.12.3 Quarters for Unaccompanied Enlisted Personnel

Quarters for Unaccompanied Enlisted Personnel

OSAF uses two costs for every RPLANS major unit that has enlisted military personnel: 1) the cost before the unit moves and 2) the cost if the unit moves. Once again, the method is similar to the one used for married enlisted for the cost before the unit moves, but the method is different for units that do move.

- Starting location
  - Key assumption: Housing cost is a weighted average of 1) cost of on-post housing and 2) private sector housing (housing allowances).
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill requirement not met by on-post housing.
  - Cost: Maintenance cost for quarters and housing allowances for private sector housing.
- Gaining location
  - Key assumption: 100% of requirement filled by UEPH on base.
  - Demand: RPLANS (unit size).
  - Supply: Surplus assets on base plus construction.
  - Cost: Maintenance cost of quarters

Figure G-29. Quarters for Unaccompanied Enlisted Personnel

The Cost Before Moving (Enlisted)

There are three steps to compute this estimate:

1. Determine the maintenance cost of all Unaccompanied Enlisted Personnel Housing (UEPH) based on ISR estimates.
2. Estimate the number of unaccompanied enlisted personnel living on housing allowances.
3. Calculate the unit cost of UEPH and allowances.

1. Determine the maintenance cost of all Unaccompanied Enlisted Personnel Housing (UEPH) based on ISR estimates.

Isr_{im} = ISR maintenance cost to sustain conditions at installation i type m.

Note: utilities and operations for these units are a part of BOS cost. Since these costs are already covered by the BOS model, only maintenance and repair costs are covered here.

2. Estimate the number of unaccompanied enlisted personnel living on housing allowances.

$$Alw_{im} = \max \sum_{u \in IS_i} (Munit_{um} * \%U_m) - AHsg_{im\text{"UEPH"}}, 0$$

$$\forall\ i, m = \text{enlisted}$$

3. Calculate the unit cost of UEPH and allowances.

$$HCost_{mudi} = \frac{(Isr_{im} + Allow_{md} * Alw_{im})}{\sum_{u} (Munit_{um} * \%U_m)}$$

$$\forall\ u, i, m\text{=enlisted}, d\text{=unaccompanied}$$

The Cost if Moved (Enlisted)

Unlike the case with married enlisted, OSAF assumes that a unit that moves finds 100 percent of its requirement in unoccupied UEPH or newly constructed UEPH. The unit cost of these UEPH units is equal to the ISR cost at the installation to maintain the space (if new UEPH is required then a construction cost is also included).

G.12.4 Quarters for Unaccompanied Officers

Quarters for Unaccompanied Officers

OSAF uses two costs for every RPLANS major unit that has officers: (1) the cost before the unit moves and (2) the cost if the unit moves.

- ❑ Starting location
  - Key assumption: Housing cost is a weighted average of 1) cost of on-post housing and 2) private sector housing (housing allowances).
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill requirement not met by on-post housing.
  - Cost: Maintenance cost for quarters and housing allowances for private sector housing.
- ❑ Gaining location
  - Key assumption: Private sector can fill 100% of requirement.
  - Demand: RPLANS (unit size).
  - Supply: Private market can fill 100% of the requirement.
  - Cost: Housing allowances

Figure G-30. Quarters for Unaccompanied Officers

The Cost Before Moving (officers)

There are 3 steps to compute this estimate:

1. Determine the maintenance cost of all Unaccompanied Officer Personnel Housing (UOPH) based on ISR estimates.

Isr_{im} = ISR maintenance cost to sustain conditions at installation i type m.

Note: utilities and operations for these units are a part of BOS cost. Since these costs are already covered by the BOS model, only maintenance and repair costs are covered here.

2. Estimate the number of unaccompanied officer personnel living on housing allowances.

$$Alw_{im} = \max \sum_{u} (Munit_{um} * \%U_m) - AHsg_{im"UOPH"}, 0$$

$$\forall\, i, m = \text{officer}$$

3. Calculate the unit cost of UOPH and allowances.

$$HCost_{mudi} = \frac{(Isr_{im} + Allow_{md} * Alw_{im})}{\sum_{u} (Munit_{um} * \%U_m)}$$

$$\forall\, u, i, m = \text{officer}, d = \text{unaccompanied}$$

The Cost if Moved (Officer)

As with married officers, OSAF assumes that a unit that moves finds 100 percent of its housing in the private market. Hence, its housing requirement is paid for through housing allowances at the gaining installation (equation #3 above where i = gaining installation).

APPENDIX H BRAC 95 AND OSAF RELATIONSHIPS

H.1 BRAC 95 and OSAF

This appendix provides an overview of how COBRA/URCM fit into an OSAF Stationing Analysis. Figure H-1 illustrates the past BRAC process, how COBRA was used to examine stationing alternatives, and how OSAF uses URCM.

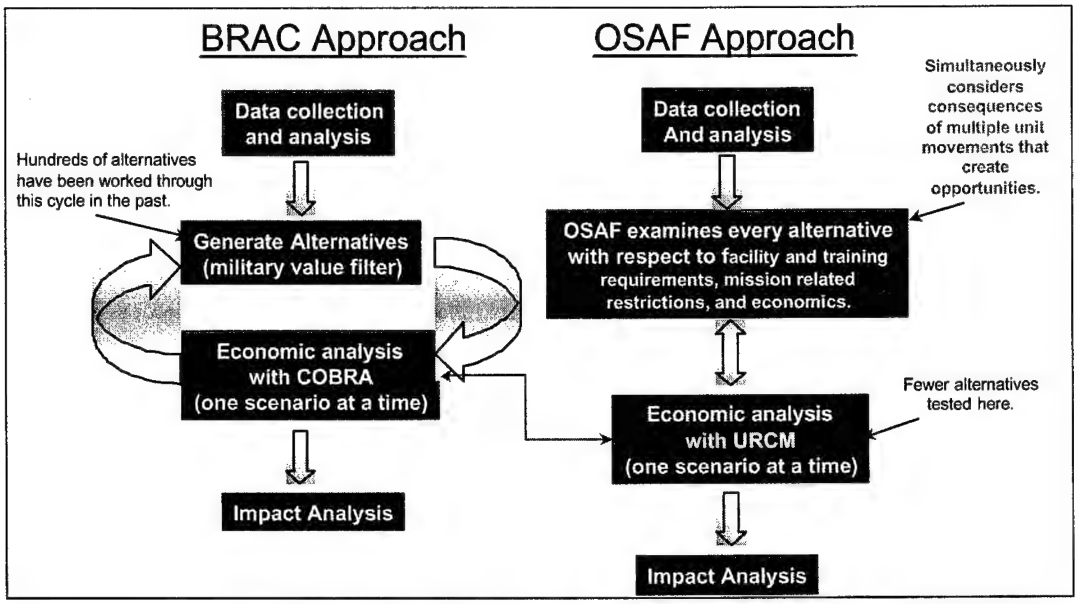


Figure H-1. BRAC and OSAF Approaches

In the past, stationing alternatives were generated by panels, teams, and leadership and then tested through the COBRA model for their economic payback. A team would examine COBRA results and then generate new alternatives. Hundreds of scenarios were generated in this fashion. In fact, the OSAF team collected 692 COBRA scenarios that were run in past BRAC exercises.

This approach is labor intensive and takes considerable time to investigate alternatives and load required data into COBRA. The time issue leads to a second, more fundamental problem: it is highly unlikely that this process will lead to an optimal solution in terms of cost; there is not enough time to explore all possible options. When you add this to COBRA's limited capacity to simultaneously examine a broad range of installations, analytical teams could not see the total Army cost picture; they could only see segments.

Under the OSAF approach, proposals are still validated through a cost model, URCM, which is an updated COBRA. Fewer iterations are needed to arrive at a complete Army recommendation because OSAF generates stationing solutions based on a total installation picture, instead of segments that are later cobbled together. OSAF provides optimal alternatives in terms of cost, so there is less need to test multiple scenarios in a detailed cost model. OSAF completes model runs quickly (typically less than 5 minutes). Despite the virtues of the OSAF model, solutions

need to be validated by URCM because OSAF does not include all installations or cover *all* facility category codes and does not handle special, one-of-a-kind situations. URCM, which can be adapted to cost out unique requirements, still fills this critical role. Figure H-2 provides a summary of the models' present value approaches.

- URCM uses present value (PV) of savings to measure the financial merit of a proposed action.
- Therefore, OSAF adopts a similar PV approach.
  - All the key cost elements and drivers.
  - Same discounting techniques.
- OSAF adopts the PV approach, but it is more powerful.
  - Computes PV across 43 installations instead of a single scenario.
  - Determines a solution which will minimize stationing PV across the 43 installations.
- There are differences between approaches:
  - The timing of costs.
  - The treatment of labor and personnel.
  - Cost estimating techniques.

Figure H-2. OSAF and URCM: Similarities and Differences

One of the key outputs of URCM is the present value (PV) determination of savings for a given scenario. In past closures and realignments, it was crucial to show that a proposed scenario provided savings after discounting for PV.

The OSAF model adopts this same PV approach; however, it is much more powerful for two reasons. First it computes the PV of stationing for all units across 43 installations, instead of a single scenario consisting of a few installations. Secondly, it determines a solution that minimizes total Army stationing costs (maximizes savings) across the 43 installations. Using URCM, it would be difficult to examine all stationing variations.

Differences between approaches exist in the following three key areas:

(1) The Timing of Costs. URCM determines the timing of costs and savings after the user fills out a detailed schedule showing year-by-year personnel reductions at losing installations and increases at gaining installations. This approach is not suitable for examining a high volume of stationing possibilities. Instead OSAF took the cost profiles of 53 COBRA scenarios from past base closure/realignment exercises to estimate the timing of costs. Appendix D provides additional details on this approach.

(2) The Treatment of Labor and Personnel. URCM is highly focused on counting people reductions and computing labor savings based on average salary. It then computes nonlabor costs for various programs like BOS, RPM, etc. With this approach it is impossible to determine whether the labor savings are BOS savings, RPM savings, mission savings, etc. Without this programmatic detail, the labor estimates are useless for modeling and audit purposes. OSAF models at a programmatic level. It models all BOS costs together, labor and nonlabor. The same applies to RPM and housing management costs.

(3) Cost Estimating Techniques. The techniques OSAF uses to estimate all costs closely parallel URCM; however, in some cases, different techniques were used because (1) the sponsor favored another methodology, (2) the technique was unsuitable for producing a high volume of estimates, or (3) the technique could not be used in an integer linear program. Figure H-3 highlights the differences.

Cost Element	URCM	OSAF
Base Operating Support	❑ Nonlabor only. ❑ Exponential model.	❑ Labor and nonlabor. ❑ Linear model approximating URCM exponential model.
Real Property Maintenance	❑ Nonlabor only. ❑ Exponential model.	❑Labor and nonlabor. ❑ ISR approach used at sponsor's request.
Housing	❑ Nonlabor and allowances.	❑Labor, nonlabor, and allowances.
Construction - Buildings	❑ Covers all facilities.	❑ Covers key facilities.
Construction - Ranges	❑ Covers all ranges.	❑ Covers key ranges.
Program Costs	❑ Based on user input.	❑ Based on regression of past user input.
Moving	❑ Detailed buildup based on user input.	❑ Based on CEAC and MTMC databases
Personnel	❑ Based on average salary.	❑ Included in other estimates.

Figure H-3. OSAF and URCM: Cost Estimating

H.2 The Army BRAC 95 Process

Figure H-4 provides an overview of the Army BRAC 95 process. If the Army used OSAF for BRAC, all the same inputs would still be in place. The primary differences would be:

(1) The stationing team uses OSAF to develop and examine stationing alternatives and then completes further analysis using URCM.

(2) Units and installations are study candidates and can be restationed (units) or inactivated (installations). Several exceptions exist due to unique requirements or Army strategic concerns and are highlighted in Appendix J.

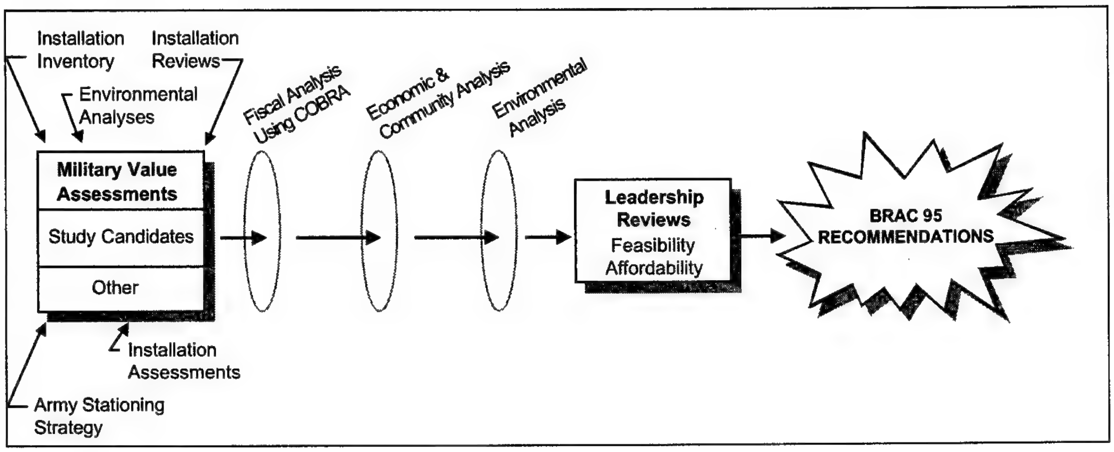


Figure H-4. The Army BRAC 95 Process

H.3 Military Value Taxonomy

Military value played an important role in past BRAC actions. OSAF considers a majority of the military value categories, but there are some that are not modeled explicitly in OSAF. The reason for exclusion falls into three areas--data availability, modeling capability, or beyond project scope.

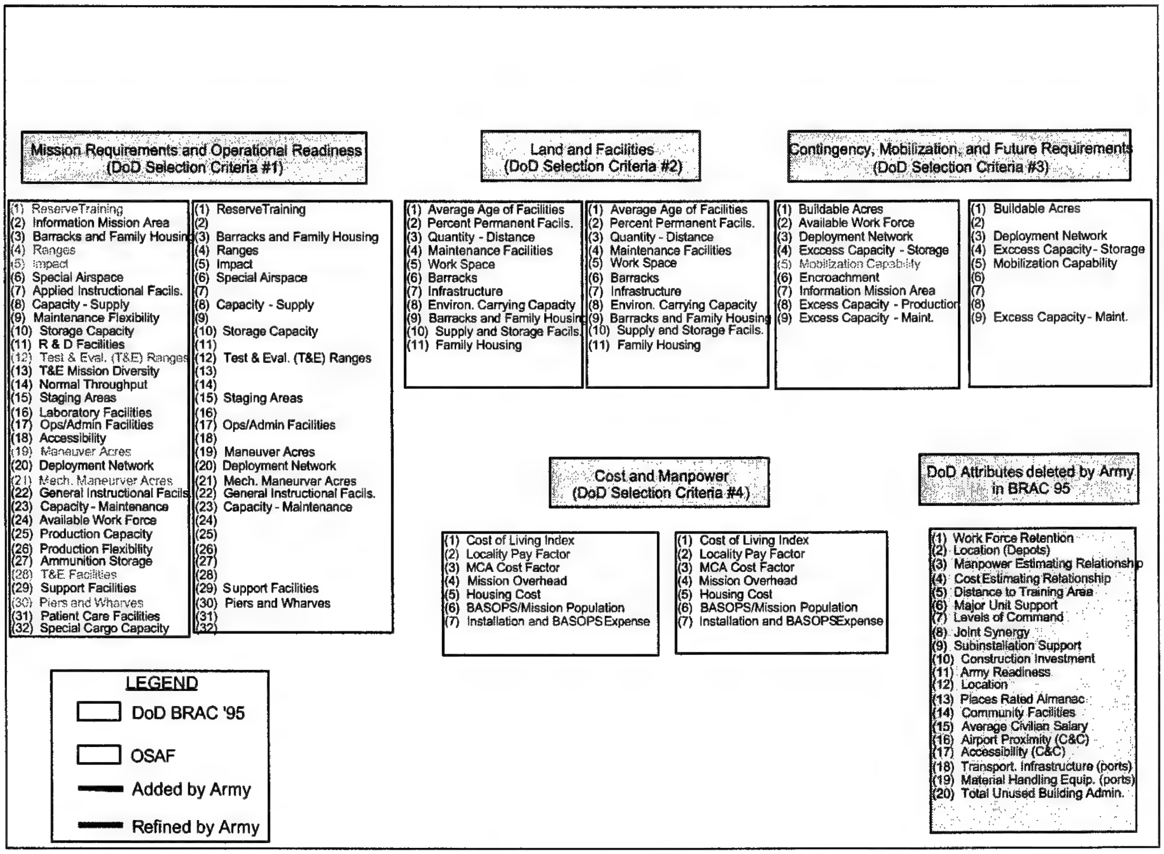


Figure H-5. Military Value Taxonomy

Data availability and project scope are self-explanatory. Modeling capability refers to the ability to model a factor mathematically. For example, encroachment is a factor that could influence different stationing decisions; OSAF does not specifically model encroachment. Instead, we address the impacts or the possible restrictions on an installation by limiting additional assets beyond existing buildings or disallowing changes in maneuver land shortages.
It is not necessary to model all military value categories in OSAF because we focus on requirements and capacities and we can capture possible implications of other categories through an impact assessment of an alternative.

Figure H-5 displays the BRAC 95 military value categories (blue) and the categories OSAF includes (yellow). All aspects of military value are included in the assessment process and could be included in the OSAF impact assessment (including aspects not listed in Figure H-5).

APPENDIX I INSTALLATIONS IN OSAF

1.1 Installations

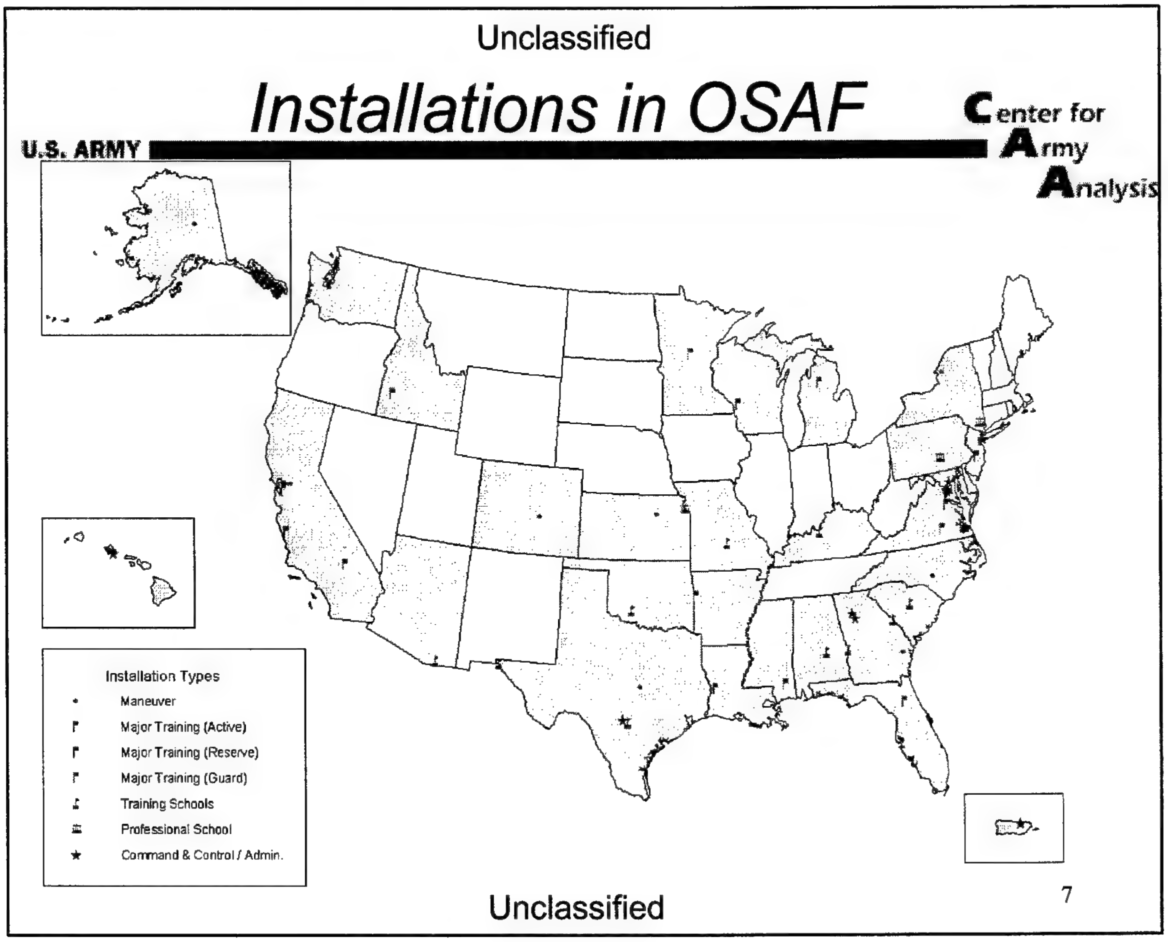


Figure I-1. Installations

1.2 Installations

Maneuver

- Fort Bragg
- Fort Campbell
- Fort Carson/PCMS
- Fort Drum
- Fort Hood
- Fort Lewis/Yakima
- Fort Richardson
- Fort Riley
- Fort Stewart
- Fort Wainwright/Greely
- Schofield barracks

Major Training (Active)

- Fort AP Hill
- Fort Irwin
- Fort Polk

Professional Schools

- Carlisle Barracks
- Fort Leavenworth
- Fort McNair
- West Point

Training Schools

- Fort Benning
- Fort Bliss
- Fort Eustis/Story
- Fort Gordon
- Fort Huachuca
- Fort Jackson
- Fort Knox
- Fort Lee
- Fort Leonard Wood
- Fort Rucker
- Fort Sam Houston
- Fort Sill
- Ordnance School at Aberdeen

Command & Control/

Administrative Support

- Fort Belvoir
- Fort Buchanan
- Fort Hamilton
- Fort McPherson/Gillem
- Fort Meade
- Fort Monroe
- Fort Myer
- Fort Shafter

Key Assumption: Army reserve and guard units and non-DOD tenants will remain on a their base if it is deactivated.

Figure I-2. Installations

1.3 Installations Not Covered in OSAF

COMMODITY ORIENTED INSTALLATIONS
- ADELPHI LABS, MARYLAND09
- NATICK LABS, MASSACHUSETTS
- REDSTONE ARSENAL, ALABAMA
- FORT DETRICK, MARYLAND
- FORT MONMOUTH, NEW JERSEY
- DETROIT ARSENAL, MICHIGAN
- ROCK ISLAND ARSENAL, ILLINOIS
- PICATINNY ARSENAL, NEW JERSEY
- COLD REGIONS RESEARCH & ENGR LAB,NEW HAMPSHIRE

AMMUNITION PRODUCTION
- IOWA ARMY AMMUNITION PLANT, IOWA
- LAKE CITY ARMY AMMUNITION PLANT, MISSOURI
- LONE STAR ARMY AMMUNITION PLANT, TEXAS
- McALESTER ARMY AMMUNITION PLANT, OKLAHOMA
- MILAN ARMY AMMUNITION PLANT, TENNESSEE
- PINE BLUFF ARSENAL, ARKANSAS
- RADFORD ARMY AMMUNITION PLANT, VIRGINIA

AMMUNITION STORAGE
- BLUE GRASS ACTIVITY, KENTUCKY
- HAWTHORNE ARMY AMMUNITION PLANT, NEVADA
- PUEBLO ARMY DEPOT ACTIVITY, COLORADO
- SIERRA ARMY DEPOT, CALIFORNIA
- TOOELE ARMY DEPOT, UTAH
- UMATILLA ARMY DEPOT ACTIVITY, OREGON

DEPOT INSTALLATIONS
- ANNISTON ARMY DEPOT, ALABAMA
- LETTERKENNY ARMY DEPOT, PENNSYLVANIA
- RED RIVER ARMY DEPOT, TEXAS
- TOBYHANNA ARMY DEPOT, PENNSYLVANIA

PROVING GROUND INSTALLATIONS
- ABERDEEN PROVING GROUND, MARYLAND
- DUGWAY PROVING GROUND, UTAH
- WHITE SANDS MISSILE RANGE, NEW MEXICO
- YUMA PROVING GROUND, ARIZONA

INDUSTRIAL FACILITIES
- DETROIT TANK PLANT, MICHIGAN
- LIMA ARMY PLANT, OHIO
- WATERVLIET ARSENAL,NEW YORK

PORT INSTALLATIONS
- MILITARY OCEAN TERMINAL OAKLAND, CALIFORNIA
- MILITARY AMMUNITION TERMINAL SUNNY POINT, NC

MEDICAL CENTER INSTALLATIONS
- WALTER REED ARMY MEDICAL CENTER, DC

Figure I-3. Installations Not Covered in OSAF

Figure I-3 lists most major Army installations that we do not include in OSAF. The primary reason for exclusion is the different "demand-supply" relationships that would need to be developed to incorporate the above installations. Such relationships justify a separate model and/or extensive research and data collection. [Draft Army Stationing Strategy, Appendix A, July 2001]

Every installation above could be added to OSAF and used as a destination for units. But OSAF could not optimally station/realign above installation types without the demand-supply relationships.

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APPENDIX J STATIONING RESTRICTIONS

OSAF limits constraints that impact possible stationing alternatives in an attempt to examine the largest possible solution space; however, there are instances where an installation or unit characteristic forces a stationing restriction. Below is a list of example stationing restrictions developed in cooperation with CAA, ODCSOPS, and ACSIM (as of July, 2001). Additional restrictions may be necessary as we continue to examine alternatives.

- Group major units (e.g., six units at Fort Carson from 4th ID "grouped" into one unit).
- USAR and ARNG units do not move.
- USDB in Leavenworth is fixed.
- Field Artillery School must have impact area as least as big as the impact area at Fort Sill.
- National Security Agency does not move from their hardened facility at Fort Meade.
- Apache Training Bde can be stationed at: Hood, Carson, or Bliss.
- West Point, Ft Irwin, and NG/Reserve training sites are fixed open.
- Restrict Old Guard to Fort Myer or Fort McNair.
- Military District Washington restricted to the National Capital Region.
- The Health School at Fort Sam Houston is only eligible to move to installations with an Army Medical Clinic.
- Fix the tenants (most have a medical mission) at Fort Sam Houston along with the medical clinic.

Installations that in effect are "forced open" by these stationing rules are listed in Figure J-1. The installation is forced open in OSAF; however, units can still be restationed to and from these installations.

Installations Fixed Open	Specific Unit forcing the Open Requirement
Fort Leavenworth	USDB
Fort Meade	NSA
Fort McNair or Myer	Old Guard
Fort Sam Houston	Medical tenants
West Point	N/A – Activity requirement
Fort Irwin	N/A – Activity requirement
NG/Reserve Training Sites	N/A – Activity requirement

Figure J-1. Installations Forced Open

APPENDIX K MANEUVER LANDS

Figure K-1 lists the heavy and light KM^{2}Days available in the Army [ATSC, July 2001, subject to change]. We can quickly see from the figure that the proponderance of both light and heavy maneuver lands are on a small number of installations. Even if lands are available at a site, other constraining factors could limit a restationing that could take advantage of these lands (e.g., cost, buildable acres, encroachment, national defense issues).

Installation	HEAVY KM2	LIGHT KM2	NET KM2	HEAVY KM2 x DAYS	% of Total	LIGHT KM2 x DAYS	% of Total	NET KM2 x DAYS	% of Total	Cum. Total
FT RICHARDSON	2080	1210	3290	503360	18.5%	292820	14.3%	796180	16.7%	16.7%
WAINWRIGHT	190	2844	3034	46030	1.7%	688148	33.5%	734178	15.4%	32.0%
Greely-AK	1326	727	2053	320892	11.8%	175934	8.6%	496826	10.4%	42.4%
IRWIN	1312	665	1977	317504	11.7%	160930	7.8%	478434	10.0%	52.4%
BLISS	1244	0	1244	301048	11.0%	0	0.0%	301048	6.3%	58.7%
YAKIMA	551	621	1172	133342	4.9%	150282	7.3%	283624	5.9%	64.7%
PINION	904	0	904	218768	8.0%	0	0.0%	218768	4.6%	69.2%
POLK	190	531	721	45980	1.7%	128550	6.3%	174530	3.7%	72.9%
STEWART	656	0	656	158633	5.8%	0	0.0%	158633	3.3%	76.2%
CARSON	378	0	378	91476	3.4%	0	0.0%	91476	1.9%	78.1%
HOOD	332	45	377	80344	2.9%	10769	0.5%	91113	1.9%	80.0%
BRAGG	210	156	366	50820	1.9%	37752	1.8%	88572	1.9%	81.9%
DRUM	318	0	318	76956	2.8%	0	0.0%	76956	1.6%	83.5%
Dugway	70	219	289	16940	0.6%	52998	2.6%	69938	1.5%	85.0%
BENNING	175	104	278	42239	1.5%	25047	1.2%	67286	1.4%	86.4%
KNOX	154	120	274	37268	1.4%	29040	1.4%	66308	1.4%	87.7%
CAMPBELL	250	6	256	60379	2.2%	1500	0.1%	61879	1.3%	89.0%
LEWIS	12	239	251	2904	0.1%	57838	2.8%	60742	1.3%	90.3%
PTA - Hawaii	77	154	231	18634	0.7%	37268	1.8%	55902	1.2%	91.5%
HUACHUCA	37	185	222	8954	0.3%	44867	2.2%	53821	1.1%	92.6%
Chaffee	219	0	219	52998	1.9%	0	0.0%	52998	1.1%	93.7%
SCHOFIELD	60	135	195	14520	0.5%	32670	1.6%	47190	1.0%	94.7%
RILEY	194	0	194	46979	1.7%	0	0.0%	46979	1.0%	95.7%
AP HILL	187	0	187	45254	1.7%	0	0.0%	45254	0.9%	96.6%
RUCKER	4	151	155	968	0.0%	36542	1.8%	37510	0.8%	97.4%
SILL	0	139	139	0	0.0%	33638	1.6%	33638	0.7%	98.1%
JACKSON	0	131	131	0	0.0%	31702	1.5%	31702	0.7%	98.8%
ABERDEEN	49	53	102	11858	0.4%	12753	0.6%	24611	0.5%	99.3%
Camp Bullis	65	10	75	15730	0.6%	2420	0.1%	18150	0.4%	99.7%
LEONARD WD	1	39	39	218	0.0%	9317	0.5%	9535	0.2%	99.9%
GORDON	17	0	17	4187	0.2%	0	0.0%	4187	0.1%	100.0%
EUSTIS/STORY	0	3	3	0	0.0%	726	0.0%	726	0.0%	100.0%
Fort Lee	0	3	3	0	0.0%	726	0.0%	726	0.0%	100.0%
Totals:	11261	8489	19750	2725183		2054237		4779421		
day factor for km2days:	242									
Source: ATSC, July 2001										

Figure K-1. Army Maneuver Lands

Heavy maneuver lands are defined as:

Space for ground and air combat forces to practice movements and tactics during amphibious (ship-to-shore) operations. Different type units may work in support of one another (combined arms), or the unit may operate on its own to practice a specific set of ARTEP tasks. The "heavy" designation refers to areas where maneuver is unrestricted and can consist of all types of vehicles and equipment, including tracked vehicles. "Heavy" maneuver /training areas can be used for "light" forces. Included in these areas are bivouac sites, base camps, and other miscellaneous training areas. [DA PAM 415-28, App. B].

Light maneuver lands are defined as:

Space for ground and air combat forces to practice movements and tactics during amphibious (ship-to-shore) operations. Different type units may work in support of one another (combined arms), or the unit may operate on its own to practice a specific set of ARTEP tasks. The "Light" designation refers to areas where maneuver may be restricted for some reason to only small units or units having only wheeled vehicles. "Light" maneuver /training areas are not typically used by "heavy" forces other than assembly areas where movement is restricted to roads or trails. Included in these areas are bivouac sites, base camps, and other miscellaneous training areas. [DA PAM 415-28, App. B].

The maneuver land requirement for large Army units is a model constraint that limits restationing actions. Figure K-2 lists major Army units and their maneuver requirements. If we compare supply (installations) to demand (unit requirements) then the number of installations that can satisfy unit demands is limited.

UNIT	UNIT_SHORT_NAME	Installation	Requirement HV_MNVR	Requirement LT_MNVR
172nd BDE	172nd IN BDE +516th SIGNAL + CORPS	RICHARDSON	0	30310
	172nd IN BDE +516th SIGNAL + CORPS	WAINWRIGHT-GREELY	0	68457
1st	1st & 3rd BDE 1st ID + UNITS	RILEY	88428	55144
1st CAV	1st CD	HOOD	223563	70603
2nd	3rd BDE 2nd ID + GRPS	LEWIS	42572	20630
3rd	1st & 2nd BDE 3rd ID + DIV UNITS	STEWART-HUNTER AAF	154479	56982
	BDE 3rd ID + 36th ENGR	BENNING	67344	30308
4th	3rd BDE 4th ID + DIV Units	CARSON	67691	35546
10th	1st & 2nd BDE 10th ID + DIV UNITS	DRUM	0	188844
25th	2nd & 3rd BDE 25th ID + DIV UNITS	SCHOFIELD	0	181919
	1st BDE 25th ID + GRPS	LEWIS	0	76089
101st	101st DIV	CAMPBELL	0	243131
82nd	XVIII CORPS + 82nd ABN DIV	BRAGG	0	259870
3rd ACR	3rd ACR +43rd SPT	CARSON	47484	15285
SOCOM	SOCOM	STEWART-HUNTER AAF	0	21314
	SOCOM	LEWIS	0	21314
75th RGR	75th RGR RGT	BENNING	0	21362

Figure K-2. Maneuver Requirements (KM^2 days)

Figure K-3 takes the land distribution a step farther and links capacities to requirements. The red in Figure K-3 represents a shortage in maneuver lands. Again we see the proponderance of excess lands are in Alaska. The last column allows light maneuver requirements to use excess heavy lands. We see that this helps alleviate shortfalls on three installations and decreases shortfalls on four other installations (requirements and capacities are subject to change).

Installation	Capacity Heavy	Capacity Light	Requirement Heavy	Requirement Light	CAP-REQ Heavy	CAP-REQ Light	CAP-REQ Light use Heavy
OVERALL	**294.92**	**219.58**	**116.21**	**197.28**	**178.71**	**22.30**	**84.13**
Inst. Short					**-42.54**	**-140.07**	**-110.65**
Inst. Over					**221.25**	**162.36**	**194.78**
Richardson	50.34	29.28		3.05	50.34	26.23	26.23
Wainwright/Greely	36.69	86.41		6.85	36.69	79.56	79.56
Irwin	31.75	16.09	4.34	0.50	27.41	15.59	15.59
Carson/Pinion	31.01		11.52	6.40	19.49		13.09
Bliss	30.11		9.79	2.99	20.32		17.33
Stewart	15.86		16.36	9.19			
Lewis/Yakima	13.63	20.81	4.26	16.05	9.37	4.76	4.76
Hood	8.03	1.08	40.24	11.49			
Drum	7.70		5.17	23.42	2.52		
Campbell	6.04	0.15	0.36	24.71	5.68		
Bragg	5.08	3.78	0.41	27.12	4.67		
Riley	4.70		10.50	6.37			
Polk	4.60	12.86	1.27	8.35	3.33	4.50	4.50
Benning	4.22	2.51	6.79	12.97			
Schofield/PTA	3.33	7.00		19.43	3.33		
Knox	3.73	2.90	5.20	1.95		0.95	

Figure K-3. KM²Days Disposition (0000)

Figure K-3 is limited to lands on OSAF installations.

APPENDIX L MEDICAL

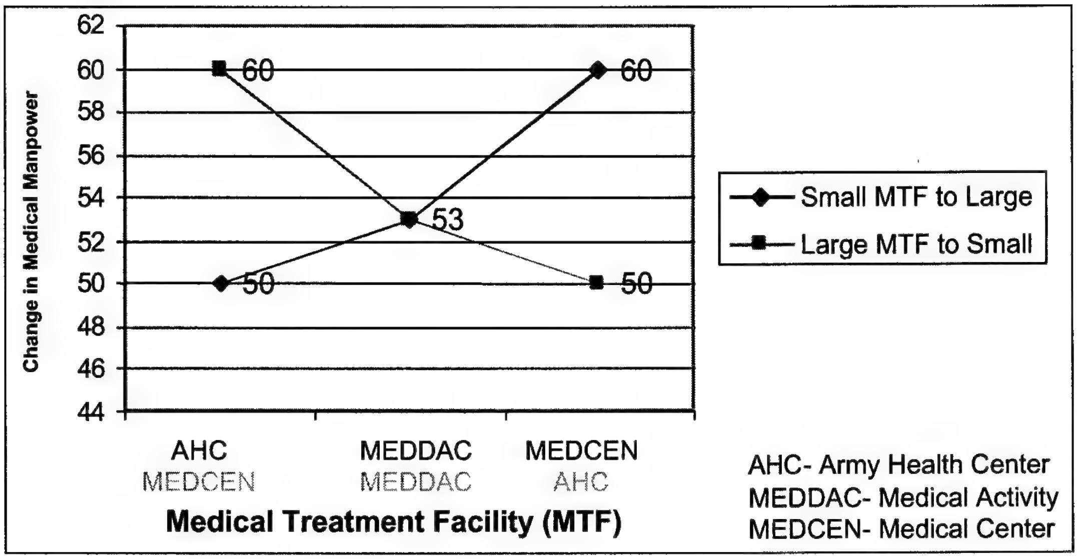

Figure L-1. Change in Medical Manpower Requirements (plus or minus one brigade)

As part of the OSAF analysis, CAA examined the impact that shifts in the stationing of Army forces would have on medical manpower requirements at the sending and receiving installations. CAA requested the Office of the Surgeon General (OTSG) provide model-based manpower requirements for consideration in the OSAF project. The OTSG responded with several sets of data, the last of which is represented in Figure L-1. The figure illustrates the effect on medical manpower requirements that a brigade realignment from an installation having one type of medical treatment facility (MTF) to an installation having a different type of MTF:

Table L-1. Brigade Realignment Impacts

Realignment	Effect on Manpower Requirements at:			Change in Total AMEDD Manpower Requirements
	AHC	**MEDDAC**	**MEDCEN**	
AHC to MEDDAC	**-50**	**+53**		**+3**
AHC to MEDCEN	**-50**		**+60**	**+10**
MEDCEN to MEDDAC		**+53**	**-60**	**-7**
MEDCEN to AHC	**+50**		**-60**	**-10**
MEDDAC to AHC	**+50**	**-53**		**-3**

The requirements in this table are based on the sum of 32 primary care providers plus variable ancillary requirements. The requirement for 32 primary care providers is based on the AMEDD Primary Care Manager (PCM) Model average (1 provider per 1,101 enrollees + 2.8 support personnel per provider). This standard was applied to the 9,384 potential enrollees (3,910 active duty Army and 5,474 dependents; ratio of 1.4/1) associated with the stationing of one brigade. (The requirements will change if the brigade size changes.)

The PCM Model provides for the following medical services:

- Primary Care,
- Family Practice,
- Pediatrics,
- Immunology,
- Physical Exams, and
- Internal Medicine

The variability in requirements among the three levels of medical treatment facilities (MTFs) results from the addition of certain ancillary support requirements that follow. The manpower requirements are derived from historical utilization rates factored by the additional 9384 potential enrollees associated with a brigade movement unless noted otherwise.

Additional Manpower Requirements

Facility Size	**MEDCEN**	**MEDDAC**	**AHC**	
Pharmacy	3.091	2.537	**3.174**	
Radiology	4.563	2.335	2.650	
Clinical Pathology	2.065	3.305	2.670	
Patient Administration	2.350	2.350	2.350	1 per 4000 records
Social Work/Family Advocacy	5.000	5.000	5.000	4 Social Workers, 1 Admin
ER/Acute Care Clinic	1.560	1.131	2.094	
In-patient Nursing	8.690	3.637	No In-Pat	
	27.319	**20.295**	**17.938**	
	+32	**+32**	**+32**	← **PCM requirements**
Whole Manpower	**60**	**53**	**50**	

OTSG: "All other demand placed on the receiving MTFf can be absorbed with existing resources."

According to the OTSG, the OSAF maneuver sites are aligned under the three MTF types as follows:

MEDCEN	MEDDAC	AHC
Ft. Bragg	Ft. Campbell	Ft. Richardson
Ft. Lewis	Ft. Carson	Ft. Drum
Schofield Barracks (Tripler AMC)	Ft. Hood	
	Ft. Riley	
	Ft. Stewart	
	Fts. Wainright/Greely	

APPENDIX M OTHER TOOLS

Figure M-1 is a listing of OSAF's primary supporting models and a short description of their primary use.

Models and Tools		Description
RPLANS	Real Property Planning and Analysis System	A facilities planning database and application.
ISR	Installation Status Report	A decision support system providing information on facilities condition, readiness, and resources.
URCM	Unit Relocation Cost Model	An economic analysis model for base closure and realignment.
ITC	Installation Training Capacity Model	Analyzes the capacity of installations to support live training.
ARRM	Army Range and Training Land Program Requirements Model	Provides the raw data for ITC.
ASIP	Army Stationing and Installation Plan	RPLANS source for personnel by unit by location.
STANFINS	Standard Financial System	Source accounting system for BOS, RPM, and housing costs.

Figure M-1. Supporting Models and Tools

Numerous other analyses will impact Army stationing decisions. Figure M-2 provides a synopsis of these analyses.

Army Facility Strategy	Available Nov 1st 2001, develops a plan for facility improvements
PBP 407 Study	Rand, Ordnance Rightsizing Study
Installations Support Cost Model, (ISCM)	PA&E, generic look at average installations and units at a macro requirements level.
ITC/ARRM Initiatives	Provides all training inputs
Officer Initial Entry Training	Consolidation of school requirements.
Facilities Requirement Impact for Transformation	Determines IBCT facility requirements.
Programmatic Environmental Impact Statement	DAMO-FD, env. impact of the IBCT, available Sept 2001.

Figure M-2. Influencing Analyses

APPENDIX N UNITS

OSAF can aggregate or group units to any level desired. Typically, we do not aggregate units unless they support each other and would move together through any restationing action. This is controlled within model-sets that limit possible unit moves. An example aggregation would be a brigade and its direct support units. If the brigade is stationed elsewhere, then the supporting units should accompany it. Figure N-1 provides an example of an aggregation of units at Fort Carson.

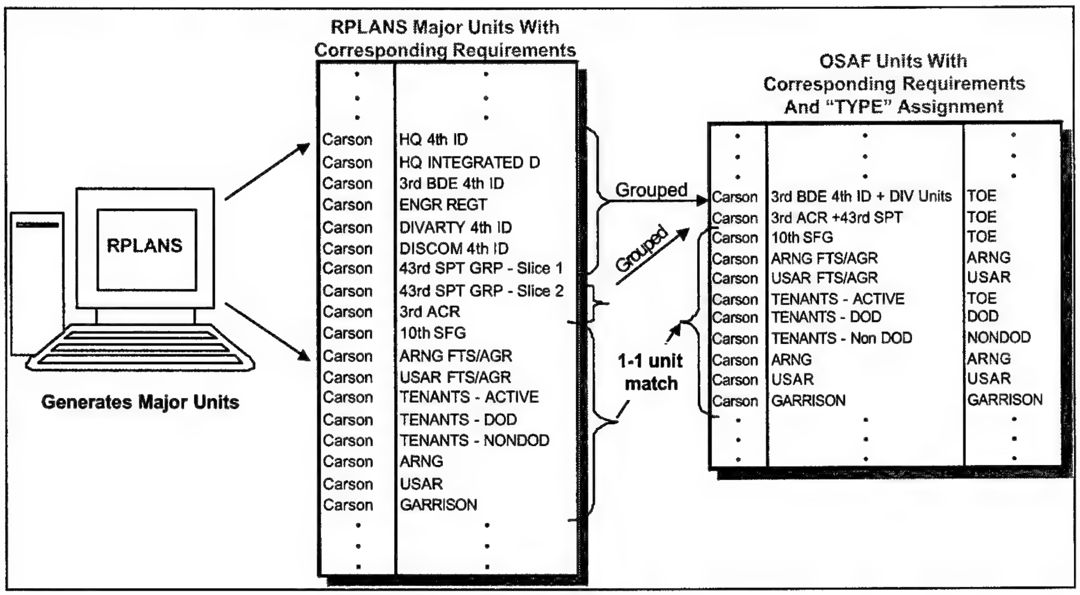

Figure N-1. OSAF Units

OSAF stations seven types of units; Figure N-2 provides a listing of these types as well as the decision rules for stationing.

OSAF TYPE	USED FOR	DECISION RULE
TOE	Units with requirements for buildings, land, and ranges.	Unit can move anywhere subject to constraints for buildings, land, ranges, and unit specific movement restrictions.
TDA	Units with requirements for buildings.	Same as TOE except land and range constraints are not applicable.
DOD	DoD units other than Army.	Model moves these units using TOE/TDA rules only if all TOE and TDA units have been moved.
ARNG	Army National Guard Units	Units are not eligible to move. Installation will deactivate leaving an ARNG enclave, if all TOE, TDA, and DOD units are moved.
USAR	U.S. Army Reserve Units	Units are not eligible to move. Installation will deactivate leaving a USAR enclave, if all TOE, TDA, and DOD units are moved.
NONDOD	Units outside DOD	Units are not eligible to move. If the installation deactivates, the model assumes the unit remains behind in an enclave or vacates the property.
GARRISON	Garrison units designated by RPLANS.	Units are not eligible to move. If all TOE, TDA, and DOD units move, then requirements and costs for this unit becomes zero and the installation deactivates.

Figure N-2. OSAF Unit Types

Table N-1 lists major RPLANS units that OSAF stations. In addition to the units listed, OSAF includes garrison units, ARNG, USAR, DOD tenants, non-DOD tenants, and active tenants at all OSAF installations (all from RPLANS).

Table N-1. OSAF Major RPLANS Units

Location	School	DOD/AMC	TDA	TOE	TOE
ABERDEEN	ORD SCH	AMC ACTIVITIES			
			ARNG FTS/AGR		
			USAR FTS/AGR		
BELVOIR		DLA	INSCOM ACT		
		DEF SYS MGT COL	HQ US CIDC		
		DEF MAP SCH			
BENNING	SCH OF AMERICAS			75th RGR RGT	
	INF CTR AND SCH			3d ID	
	CORPS TROOPS			36th ENGR GP	
BLISS	AIR DEFENSE SCH	BEAUMONT AMC			
	108th ADA BDE				
	11th ADA BDE				
	CORPS TROOPS				
	31st ADA BDE				
	35th ADA BDE				
BRAGG				HQ XVIII CORPS	18th AG BDE
				18th AVN BDE	4th PO BDE
				229th AVN REGT	HQ 82d ABN DIV
				20th ENGR BDE	1st BDE 82d
				18th CORPS ARTY	2d BDE 82d
				18th FA BDE	3d BDE 82d
				16th MP BDE	AVN BDE 82d

Location	School	DOD/AMC	TDA	TOE	TOE
				35th SIG BDE 525th MI BDE INSCOM ELEMENTS HQ 1st COSCOM 46th SPT GP 507th SPT GP 44th MED BDE	DIVARTY 82d DISCOM 82d USASOC 3d SF GP 7th SF GP USASOC CS/CSS JSOC JFK SWC AND SCH
BUCHANAN				COMBAT SUPPORT SUPPORT FORCES SPECIAL ACTV	
CAMPBELL				SOCOM HQ 101st 1st BDE 101st 2d BDE 101st 3d BDE 101st	101st AVN BDE 159th AVN BDE DIVARTY 101st DISCOM 101st CORPS TROOPS
CARLISLE	USA WAR COLLEGE				
CARSON				10th SFG HQ 4th ID HQ INTEGRATED D 3d BDE 4th ID ENGR REGT	DIVARTY 4th ID DISCOM 4th ID 43d SPT GRP 43d SPT GRP 3d ACR
DRUM				HQ 10th ID 1st BDE 10th ID 2d BDE 10th ID	AVN BDE 10th ID DIVARTY 10th ID DISCOM 10th ID COPRS TROOPS
EUSTIS-STORY	TRANS AND AVN S AVN LOG SCH			7th TRANS GP	
GORDON	SIG CTR AND SCH	EISENHOWER AMC		MI BDE CORPS TROOPS SIGNAL BRIGADE	
HOOD				APACHE TNG BDE HQ 1st CD 1st BDE 1st CD 2d BDE 1st CD 3d BDE 1st CD AVN BDE 1st CD ENGR BDE 1st CD DIVARTY 1st CD DISCOM 1st CD HQ 4th ID 1st BDE 4th ID	AVN BDE 4th ID ENGR REGT 4th I DIVARTY 4th ID DISCOM 4th ID HQ III CORPS CM BDE CORPS 504th MI BDE 89th MP BDE 3d SIG BDE 13th COSCOM 2d BDE 4th ID
HUACHUCA	INTEL CTR AND S		USAISC	SIGNAL COMMAND	
IRWIN				NTC CORPS TROOPS 11th ACR	
JACKSON	CHAPLAIN SCH USATC SOLDIER SPT CTR			CORPS TROOPS	
KNOX	ARMOR CTR AND S		USAREC	CORPS TROOPS	
LEAVENWORTH	COMB ARMS CTR		CMD TNG PROG USDB		
LEE	QM SCH LOGISTICS CTR ALMC			49th QM GRP	

Location	School	DOD/AMC	TDA	TOE	TOE
LEONARD WOOD	EN CTR AND SCH CHEMICAL SCH MP SCH			CORPS TROOPS	
LEONARD WOOD				BASIC TNG CMD 3d BT BDE	
LEWIS		MADIGAN AMC		555th ENGR GRP 62d MED GRP 593d SPT GRP 3d BDE 2d ID 555th ENGR GRP 62d MED GRP	593d SPT GRP 1st BDE 25th ID HQ I CORPS 201st MI BDE 1st PSG SOCOM 6th CID
MCNAIR	NDU		MDW		
MCPHERSON GILLEM			USARC THIRD ARMY FORSCOM		
MEADE		DEF INFO SCH NSA INSCOM ACT		CORPS TROOPS	
MONROE			TRADOC ROTC CADET CMD JT WAR CTR		
POLK				CORPS TROOPS/CENTER SLICE JRTC CORPS TROOPS/ACR SLICE 2d ACR	
RICHARDSON				172d IN BDE 516th SIGNAL BD CORPS TROOPS	
RILEY				HQ INTEGRATED D 1st BDE 1st ID 3d BDE 1st AD	937th ENGR GRP MP UNITS
RUCKER	AVN CTR AND SCH SAFETY CTR SCH OF AVN MED			CORPS TROOPS	
SAM HOUSTON	AHS	BROOKE AMC	HQ MEDCOM	CORPS TROOPS	
SCHOFIELD		TRIPLER AMC	FIFTH ARMY	HQ 25th ID 2d BDE 25th ID 3d BDE 25th ID AVN BDE 25th ID	DIVARTY 25th ID DISCOM 25th ID 516th SIGNAL BD 45th SPT GRP
SHAFTER		TRIPLER AMC	USARPAC	516th SIGNAL BD 45th SPT GRP	DISCOM 25th ID
SILL	FA SCH USATC FA			III CORPS ARTY CORPS TROOPS	
STEWART -HUNTER AAF				HQ 3d ID 1st BDE 3d ID 2d BDE 3d ID AVN BDE 3d ID	ENGR REGT DIVARTY 3d ID DISCOM 3d ID CORPS TROOPS
WAINWRIGHT -GREELY				172d IN BDE 516th SIGNAL BD CORPS TROOPS	
WEST POINT	USMA				

APPENDIX O SENSITIVITY ANALYSIS

O.1 Individual Installation Impacts

One strength of the optimization approach that OSAF uses is the ability to change parameters, cost, stationing restrictions, or installation disposition to see the impact. This appendix provides examples of sensitivity analysis we can conduct with OSAF.

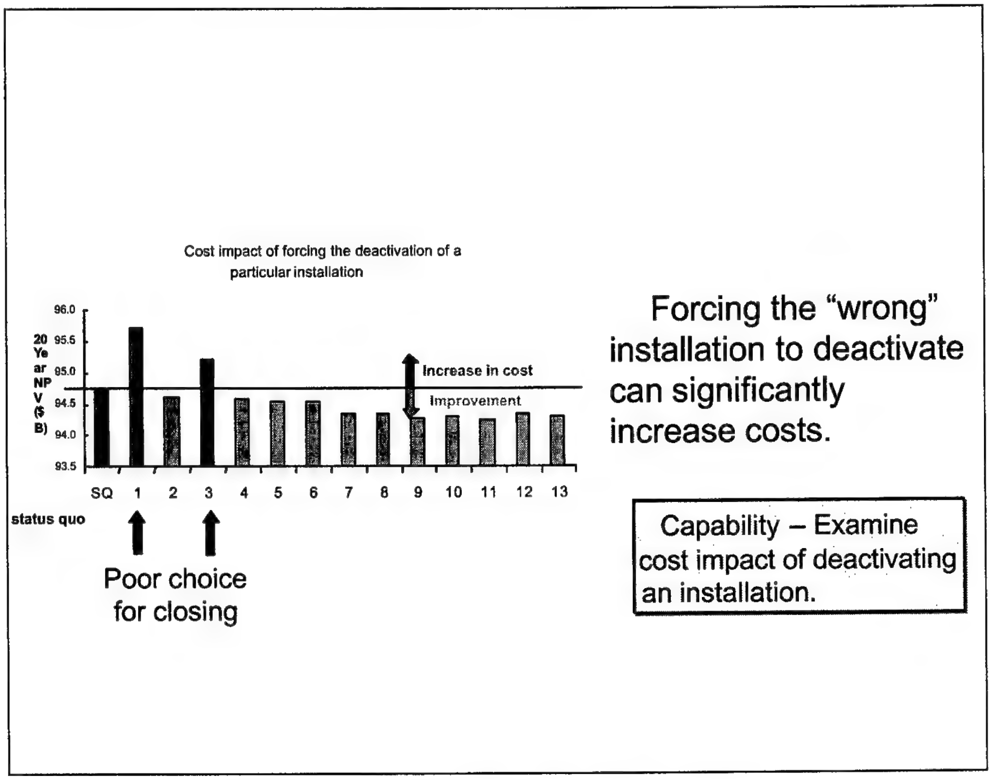

Figure O-1. Individual Installation Impacts

Figure O-1 is an example of 13 installations and the impact on cost if we force OSAF to close 1 of the 13. By closing installation #1 or #3, the resulting impact is an increase in costs. This increase could be because the installation had very low costs and the units moved to higher cost installations, or because it had units with requirements that could only be met with considerable MILCON at other installations. The example illustrates how arbitrarily closing an installation in isolation (not examining costs, facilities, ranges, and maneuver lands) does not necessarily save dollars.

O.2 Forcing an Installation to Stay Open

Figure O-2 lists a number of installations that are closed (B, D, E, F, G, H) in alternative #3 in Figure 17 in the main report. We can force one of these installations to stay open and see the

impact. For example, if we force installation B to stay open (black in column one), we see all the other installations stay closed (stay blue). However, by forcing installation F to stay open (column four), then installations D, E, and H also stay open and installation R is closed instead. The graphic illustrates how there is a complexity in each solution where a move or closure can impact numerous other actions. When we artificially control the restationing or closure possibilities, it is sometimes difficult to predetermine the impact on installations and costs. In all cases, when an installation that was closed in an optimal solution is forced open or closed when an optimal solution left it open, the overall NPV and operating costs increase.

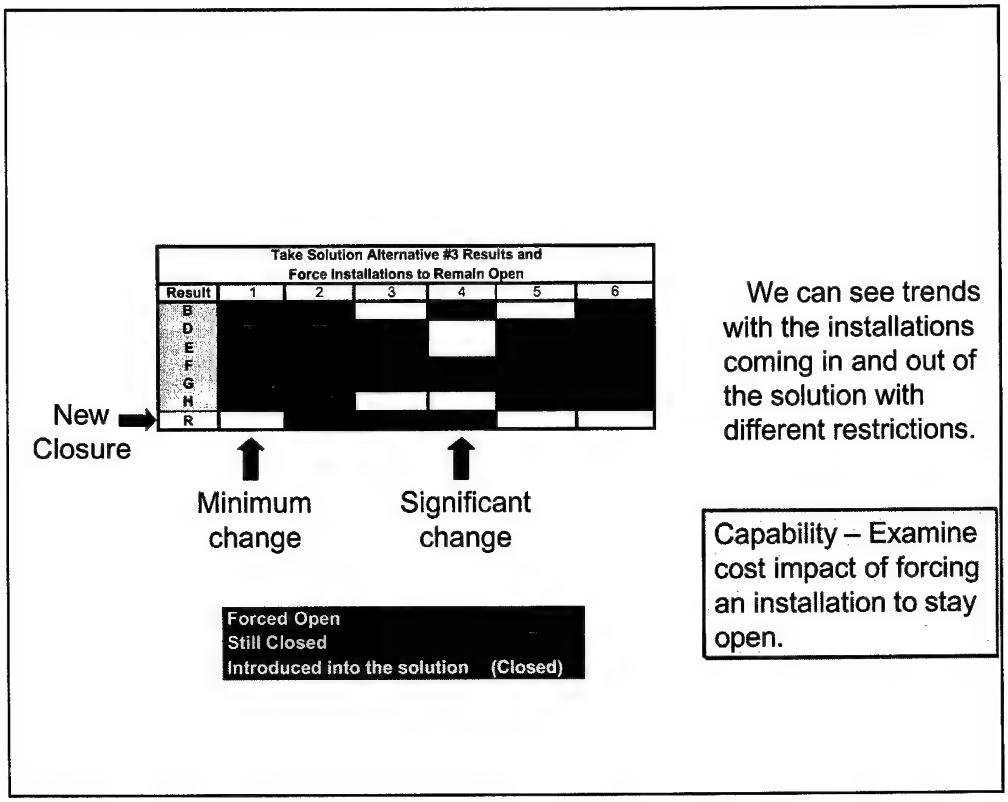

Figure O-2. Forcing an Installation to Stay Open

O.3 Allowing More Maneuver Land Shortfall

A unit's KM^2Days requirement is one of the more influential factors as far as stationing of a unit and an installation's maneuver land capacity is influential in closure actions. Relaxing the number of days an installation or the Army can be short as a whole allows additional restationing activity (starting assumption is we do not increase shortfall). In Figure O-3, we allow 10 percent additional shortfall in maneuver lands across the Army (heavy or light). In this case, we are not allowing light forces to use heavy maneuver lands (that ability will change the solution). From the figure, we can see that installations Y and Z are introduced into the solution or closed as well as the other installations in alternative #4.

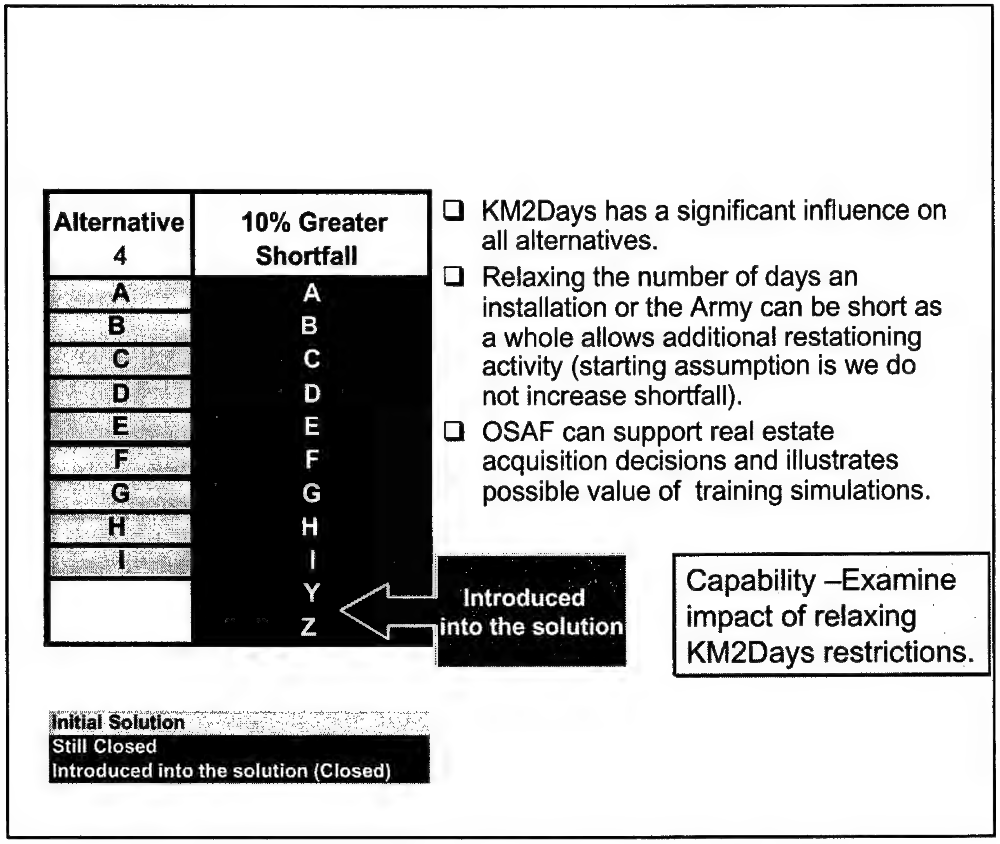

Figure O-3. Allowing More Maneuver Land Shortfall

When we allow for this shortfall, OSAF picks the installation where requirements, capabilities, and costs support additional unit assignments as long as maneuver lands are not as restrictive. This action allows us to pinpoint installations where additional maneuver land acquisitions make sense.

In all alternatives, OSAF does not close a maneuver installation unless the maneuver land shortfall is allowed to increase (above in Figure O-3) or light maneuver forces are allowed to use excess heavy maneuver lands.

The costs of conducting training on these maneuver lands is not considered due to the unknown factors that impact training costs and may unduly influence stationing actions.

O.4 Restricting Solution Based on "Military Value" (BRAC 95)

In BRAC 95, 26 installations were fixed open due to scoring high on the military value evaluations process. (OSAF forces some installations to remain open; see Appendix J). We find that a majority of installations that BRAC 95 evaluated as high in military value are also considered essential in OSAF due to their resources (facilities, ranges, and lands) and not owing to the units assigned at the installation. If we apply the BRAC 95 restrictions to alternative #4 (four installations can deactivate and five cannot), we find that of the nine installations deactivated in

this alternative (OSAF ALT. #4 column), only two can still close (New Solution in blue--B, D), and those two continue to close. The other installations remain open, and two additional installations (New Solution in red--J, L) are now closed.

Installations Fixed Open		
	BRAC 95	OSAF
Maneuver	Hood	
	Lewis	
	Bragg	
	Stewart	
	Carson	
	Campbell	
	Schofield	
	Polk	
Major Trng Areas	Irwin	Irwin
	Belvoir	
C&C	McPherson	
	Myer	
	Shafter	
	Bliss	
Training	Benning	
	Jackson	
	Knox	
	Sill	
	Gordon	
	Rucker	
	Huachuca	
	Sam Houston	
	Ft. Leavenworth	
Prof. Schools	West Point	West Point
	Carlisle	
	McNair	

Installations	OSAF ALT. #4	New Solution
A	A	
B	B	B
C	C	
D	D	D
E	E	
F	F	
G	G	
H	H	
I	I	
J		J
K		
L		L

NPV Improvement
OSAF: 5.8%
With BRAC 95 restrictions: 2.0%

Policies can have significant influence on results.

Capability – Examine impact of different installation closure restrictions.

Possible to Close
Not Possible to Close
Closed in OSAF Solution
In both Solutions
New to the restricted Solution

Figure O-4. Restricting Solution Based on "Military Value" (BRAC 95)

The restrictions had a significant impact on the solution as far as installations closing and on the NPV – BRAC 95 restrictions decreased improvements in NPV by over 50 percent (OSAF: 5.8 percent improvement, with restrictions: 2 percent improvement; see Figure O-4).

O.5 Impact of Stove Piping

Stove piping is a conscious decision to limit stationing between different types of installations, MACOMs, Services, or any other grouped installations. Here we demonstrate the impact of stove piping between installation types and MACOMs.

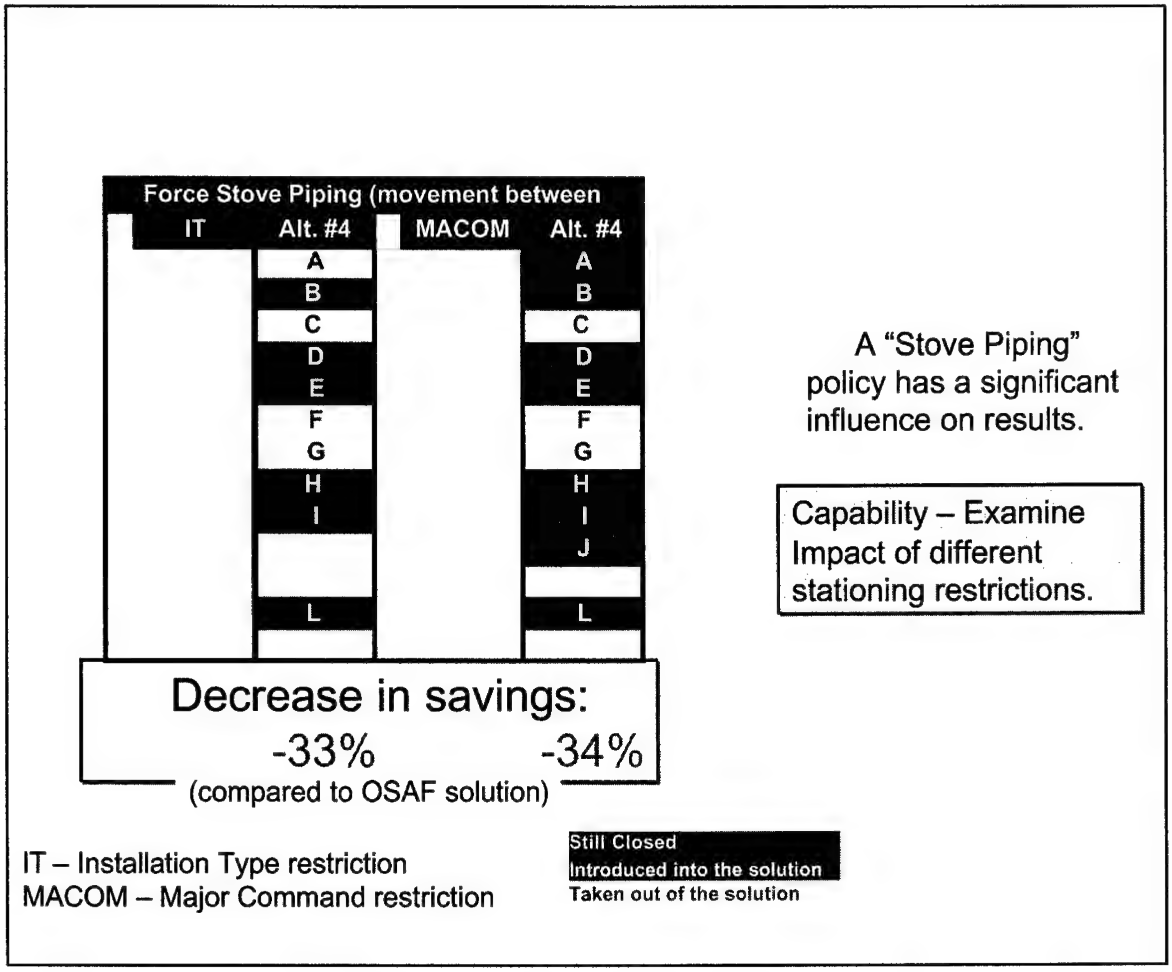

Figure O-5. Impact of Stove Piping

Stove piping decreases restationing possibilities. This restriction does not make sense from the economic, facility utilization, or land perspective. Figure O-5 illustrates how stove piping decreases the potential savings by over 30 percent if we stove pipe by installation type (IT) or by major Army command (MACOM).

When we apply stove piping to alternative #4 of Figure 17 in the main report, several installations are still closed (blue background), others remain open (red with white background), while other installations are closed instead (red background). Both cases have similar impacts in terms of cost, but influence different installations.

APPENDIX P DEPLOYMENT

Maneuver brigades have significant deployment requirements. In OSAF, installations where maneuver units are currently assigned have these assets available, and OSAF limits maneuver units to this set of possible locations through maneuver land constraints (maneuver lands is more restrictive than deployment assets).

For all installations, OSAF provides an assessment of the deployment infrastructure. For example, if the nearest port is 1,000 miles away from installation A and only 210 miles from installation B, then B has an advantage. The past BRAC processes considered the distances between an installation and different deployment assets (air, rail, sea, road) and developed a "deployment network" score based on these distances. The BRAC team saw this score as a measure of an "installation's capability to support deployment" [Vol II, p 183]. Following this logic, we have assembled a table that shows these distances and added maneuver lands (identifies possible locations for larger units) and the maximum on ground (MOG) for the nearest airfield (an indication of throughput). Major US seaports have the capability to support Army deployment of a division-size unit (~6 days); therefore, a measure for their capability is not included [MTMC/TEA Port Studies, various years].

For sea deployment, the most influential factor considered is the distance to the port. Figure P-1 shows the installations with major units, seaport of embarkation (SPOE), and aerial port of embarkation (APOE) [AR 55-15], distances [Vol II], and maneuver lands. We can see some installations have a distinct advantage as far as distance when it comes to seaports, but the airport distances are not a distinguishing factor. Obviously, to improve the Army's ability to deploy, then those installations nearer a port would be preferred. Fort Carson has the farthest distance to meet its SPOE, and on the opposite end of the spectrum, Fort Lewis is 17 miles, Schofield Barracks is 15 miles, and Fort Richardson is 7 miles. These shorter distances make a difference in times required to get to the port but do not influence the time required to deploy once at the port.

The majority of airport facilities are within 100 miles of installations, and several are collocated. More influential than distance is the MOG for the APOE, which is a measure of throughput at the APOE. To estimate throughput, we examined the AMC-MOG Reports and found the MOG for each airport and listed it for each installation. We know that for each MOG, there are a limited number of tons that can be handled and flown from the port; therefore, a higher MOG is better and provides an advantage for an airport. The MOG is listed in Figure P-1 for both the working and contingency categories per AMC-MOG stationing reports. We know from the Enabling Strategic Responsiveness (ESR) study that the MOG at CONUS airports is not the restricting factor for deployment. The restricting factor is OCONUS contingency MOG. Even though this is the case, we provide MOG for comparison.

Contingency MOG – "...based on an estimate of additional parking spaces and equipment (beyond those used in working MOG) expected to be made available during contingency operations."

Using the above approach, we capture the mileage metrics used in past analysis and have added further insights using MOG for airports and confirmed that distance is the distinguishing factor for seaports. We use this information to conduct a macro examination of each OSAF alternative from a deployment perspective and determine the possible impacts on the Army's ability to deploy restationed units.

		Distances				Net		W/C	PSP/	
	Installation	Sea*	Air*	Rail*	Road*	Km2Days	APOE	MOG	PPP	Current Major Maneuver Units
Existing locations for major units	BENNING	261	0	0	0	67286	Lawson AAF	52 (3)	PPP	3rd Bde 3rd ID
	BRAGG	100	0	0	10	88572	Pope AFB	5/12	PPP	82nd Div
	CAMPBELL	627	0	0	4.2	61879	Campbell AAF	2/37	PPP	101st Div
	CARSON/Pinion	1095	7	0	0	310244	Peterson AFB	41 (3)	PPP	3rd Bde 4th ID, 3rd ACR
	DRUM	350	80	0	7	76956	Griffis AFB	179 (3)	PPP	1/2 Bde 10th ID
	HOOD	274	0	0	0	91113	Gray AAF	0/6	PPP	1st CAV
	LEWIS/Yakima	17	3	0	0	344366	McChord AFB	2/15	PPP	3rd Bde 2nd ID, 1st Bde 25th ID
	RICHARDSON	7	3	0	1	796180	Elmendorf	3		172nd Infantry Bde
	RILEY	727	70	0	0	46979	Forbes Field	0/24	PPP	1st INF Div
	SCHOFIELD/Shaftner	15	18	0	1	47190	Hickam	1/2		2/3 Bde 25th ID
	STEWART	40	38	0	0.25	158633	Hunter AAF	42 (3)	PPP	1/2 Bde 3rd ID
	WAINWRIGHT/Greely	365		0	1	1231004	Elmendorf	3		172nd Infantry Bde
Possible locations for major units based on maneuver lands	AP HILL	125	51	5	13	45254	Andrews AFB	2/1		
	BLISS	815	1	2	4	301048	Biggs AAF	0/6	PPP	
	HUACHUCA	560	0	69	30	53821	Davis Monthan	3 (3)	PSP	
	IRWIN	166	191	37	35	478434				
	JACKSON	110	14	7	0	31702	Charleston	37/37	PSP	
	KNOX	604	35	0	14	66308			PSP	
	POLK	105	47	0	75	174530	Alexandria	90 (3)	PPP	
	RUCKER	178	22	0	71	37510	Eglin AFB	191 (3)	PSP	
	SILL	475	58	0	0	33638	Altus AFB	128 (1)	PPP	
	ABERDEEN					24611			PSP	
	EUSTIS/STORY	0	5	0	1	726	Langley AFB	14 (3)	PPP	
	GORDON	135	10	0	3	4187				
	LEE	20	35	0	4	726			PSP	
	LEONARD WOOD	690	85	0	3	9535	Whiteman	181 (1)	PSP	
Insufficient Maneuver Lands	BELVOIR	65	13	1	4		Andrews AFB	2/1		
	BUCHANAN								PSP	
	CARLISLE	85	18	1	1					
	HAMILTON	6	15	6	0					
	LEAVENWORTH	1500	20	30	12					
	MCNAIR	42	11	15	5					
	MCPHERSON	247	25	11	2		Dobbins	2/0 (2)		
	MEADE	18	12	5	1		Dover	2/8 (2)		
	MONROE	8	6	7	2					
	MYER	45	8	12	2					
	SAM HOUSTON	200	15	3	1		Kelly	174 (1)		
	WEST POINT		0	0	1					
	CHAFFEE					52998				
	DUGWAY					69938				

Not a candidate in OSAF, but the installation does have enough maneuver land to support a large maneuver unit.

Installation does not have maneuver lands and is not a candidate for restationing a unit that would require lands.

(*Source: VOL II, DOA Installation Assessment, March 1995)

(Source for SPOE and APOE info is AR 55-1)
W/C – working/contingency MOG for aircraft from Station MOG Reports
(1) Parking [AFSAA]
(2) C5
(3) Parking MOG estimates (NIMA)

Note: PPP = power projection platform; PSP = power support platform.

Figure P-1. Deployment Considerations

APPENDIX Q FUTURE USE AND EXPANSION

Q.1 Future Use

The ODCSOPS and ACSIM will use OSAF during the 2002 stationing exercise to examine stationing alternatives. The ACSIM is currently examining stationing alternatives using OSAF.

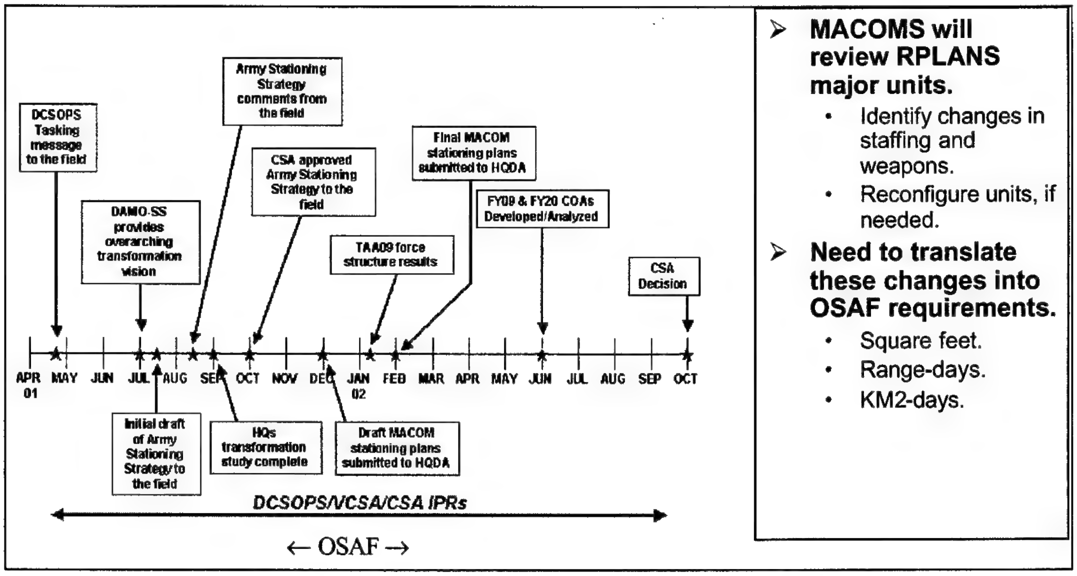

Figure Q-1. Army Structure and Stationing Analysis

Q.2 OSAF Improvement and Expansion Ideas

Before accomplishing any enhancement to OSAF, the business rules for such activity and Army-approved data sources would have to be established.

- **Expansion.**
  - OSAF Europe.
  - OSAF for Logistics Installations.
  - OSAF Korea.
  - Examine real estate acquisition impacts in detail in relation to KM2Days.

We need to prioritize!

Improvement.
  - Include other Services, National Guard, and Army Reserve land and ranges for possible restationing.
  - Add constraints for utility infrastructure (electrical, sewage, etc.) and environmental.
  - Add additional facility and range types.
  - Develop alternative objective functions (minimize maneuver land shortfall).
  - Refine separation cost factors.
  - Expand housing constraints, if possible.

Expansion requires business rules and a data source.

Figure Q-2. OSAF Improvement and Expansion Ideas

Expansion:

1. Additional functions: OSAF includes 43 Army installations and could be expanded to include some, but not all, other Army installations. In some cases a separate model (not necessarily similar to OSAF) would be required to adequately address stationing. We summarize OSAF expansion capabilities for other installations in Table Q-1.

   a. OSAF can station forces that are restationed from Europe or Korea to CONUS installations.

   b. Throughout this report we discussed potential improvements gained with Joint Service considerations. OSAF could incorporate Joint use installations and use them as destinations for Army units as well as allow other Services to use OSAF installations.

   c. National Guard and Reserve installations (and possibly training lands) are another source of possible efficiencies similar to Joint Service efficiencies.

Table Q-1. OSAF Expansion Capability

Europe/Korea	Can accept units restationed from Europe or Korea.	Cannot station all units stationed in Europe or Korea.
Commodity Installations Depots Proving Grounds Industrial Production and Storage	Can include installations as destinations for OSAF units.	Cannot optimally station logistic installation units within OSAF.
National Guard and Reserve Units	Can include installations as destinations for OSAF units and could restation larger Guard and Reserve units.	Cannot optimally station all Guard and Reserve forces.
Joint Forces	Can include other Service's installations as destinations for OSAF units and allow other Service units to use excess capacity.	Cannot optimally station other Services.

2. Real Estate Acquisition: OSAF has the ability to examine different maneuver land restrictions and the impact on stationing. When we change capacities or the percent of allowed shortages the model will choose a stationing alternative that takes advantage of additional lands. The installations chosen for increased overages are potential targets for real estate acquisition.

3. Utility infrastructure could be added to OSAF if the appropriate factors were available. USACE could possibly provide engineering level data to incorporate in pre or post-processing (discussions are ongoing with USACE).

4. OSAF is not meant to be a micro level model and as such should only include those data elements that make a difference in stationing. Other supporting models (see Appendix M) that include more FCGs could look at alternatives in more detail. Additional facility and range types could be added to OSAF if the data are available. Prior to adding facilities, we would recommend testing alternatives to see if the additional facilities make a difference in stationing decisions. Splitting UEPH, adding more community facilities, and modeling medical facilities are the most important possibilities.

5. Alternative objective functions would provide alternatives from different perspectives. For example, an alternative that minimizes maneuver land shortfall would include additional unit

moves (more implementation costs) to alleviate shortages. The alternative views provide additional information to decision makers not only on the objective, but also the cost involved.

6. Several cost factors could be refined. This type of work might not change stationing alternatives, but it will provide a more accurate accounting of costs.

7. The ACSIM no longer maintains information on all installations and their local housing. Since housing is a significant cost, additional data in this area would allow for a more accurate modeling effort for housing availability and corresponding constraints.

8. Currently OSAF handles the environmental constraints in the impact assessment. An improvement would include additional environmental constraints in the model (must have quantifiable business rules and metrics).

9. Several enhancements could be made to improve cost and saving estimates. They include:

   a. Add penalties for losing experienced employees and recruitment costs for new hiring.

   b. Add mission savings for moving from one locality pay area to another.

   c. Create a step function model for BOS.

   d. Add separation costs for garrison employees as garrisons are reduced.

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GLOSSARY

ACF	area cost factor
ACSIM	Assistant Chief of Staff for Installation Management
AEC	Army Environmental Center
AHC	Army Health Center
AMC	US Army Materiel Command
APOE	aerial port of embarkation
APV	adjusted present value
AR	Army regulation
ARNG	US Army National Guard
ARRM	Army Range and Requirements Model
ASIP	Army Stationing and Installation Plan
B	billion
BASOPS	base operations
BOS	Base Operations and Support
BRAC	Base Realignment and Closure
CAA	Center for Army Analysis
CEAC	Cost and Economic Analysis Center
CER	cost estimating relationship
CERL	US Army Construction Engineering Laboratory
COBRA	Cost of Base Realignment Actions Model
CONUS	continental United States
DAMO-FM	DCSOPS Force Management Division
DFAS	Defense Finance Acounting System
DLA	Defense Logistics Agency
DOA	Department of the Army
DOD	Department of Defense
DODI	Department of Defense Instruction
EFI	Efficient Facilities Initiative
ERCM	Environmental Regulatory Climate Model
ESMP	Endangered Species Management Plans
FCG	facility category group
FORCES	Force and Organization Cost Estimating System
FORSCOM	US Army Forces Command
FWS	Fish and Wildlife Service
FY	fiscal year
FYDP	Future Years Defense Plan
GAO	General Accounting Office
HQDA	Headquarters, Department of the Army
IBCT	interim brigade combat team

ILP	integer linear program
IPR	Installation Restoration program
ISBC	Infantry Squad Battle Course
ISCM	Installation Support Cost Model
ISR	Installation Status Report
IT	installation type
ITC	installation training capacity
JBO	jeopardy biological option
JTR	Joint Travel Regulation
KM^2Days	kilometer square days
LAW	light antitank weapon
M	million
MACOM	major Army command
MDW	Military District of Washington
MEDCEN	medical center
MEDDAC	medical activity
MILCON	Military Construction
MOG	maximum on ground
MOM	Measure of Merit
MOUT	military operations in urban terrain
MPRC	Multipurpose Range Complex
MPTR	Multipurpose Training Range
MTF	medical treatment facility
MTMC	Military Traffic Management Command
MTMC-TEA	Military Traffic Management Command – Transportation Engineering Agency
NEPA	National Environmental Policy Act
NOV	notice of violation
NPL	National Priorities List
NPL	National Priorities List
NPV	net present value
OCONUS	outside continental United States
ODCSOPS	Office of the Deputy Chief of Staff for Operations and Plans
OPTEMPO	operational tempo
OSAF	Optimal Stationing of Army Forces
OSUB	Optimal Stationing Units to Bases
OTSG	Office of The Surgeon General
PAE	Program Analyis and Evaluation
PAM	pamphlet
PCM	Primary Care Manager (model)
PCS	permanent change of station
PLS	Planning Level Survey
POM	Program Objective Memorandum
PV	present value
QDR	Quadrennial Defense Review

RAB	Restoration Advisory Board
RIF	reduction in force
RPLANS	Real Property Planning and Analysis System
RPM	Real Property Maintenace
SF	square feet
SPOE	seaport of embarkation
STANFINS	Standard Financial System
T&E	threatened and endangered
TDA	table(s) of distribution and allowances
TOE	table(s) of organization and equipment
TRADOC	US Army Training and Doctrine Command
TRC	Technical Review Committee
UEPH	Unaccompanied Enlisted Personnel Housing
URCM	Unit Relocation Cost Model
USAR	US Army Reserve
USARPAC	US Army Pacific
USARSO	US Army Forces Southern Command
USEPA	US Environmental Protection Agency
UXO	unexploded ordnance
VOC	volatile organic carbon

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